

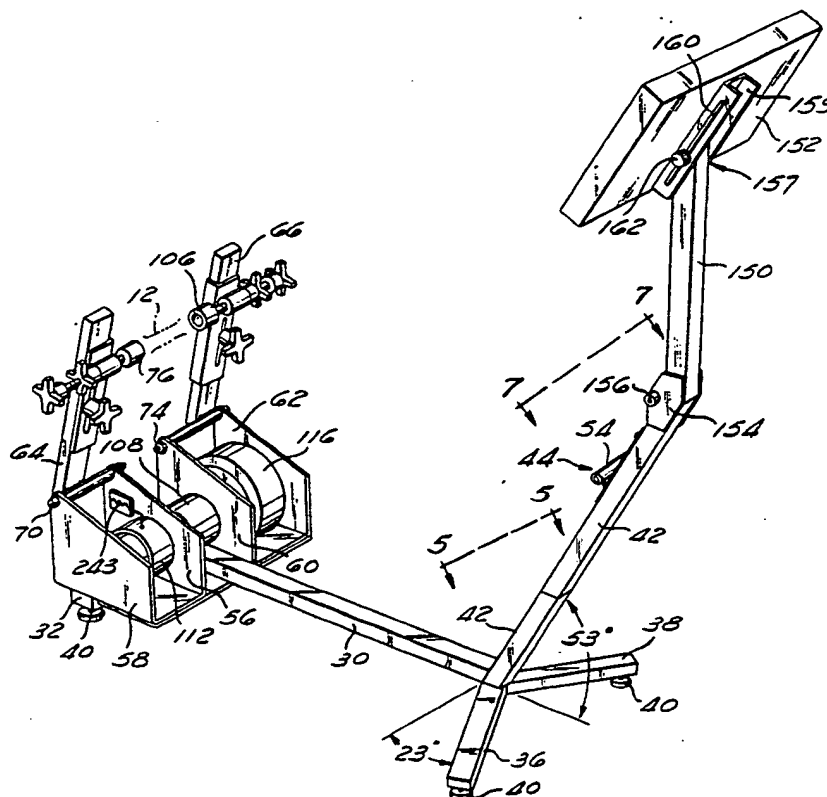
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(54) Title: **BICYCLE RACING TRAINING APPARATUS**

(57) Abstract

An exercising apparatus for supporting a bicycle, a pivotally mounted support member (64, 66) connects the rear axle (12) of the bike to constrain movement of the axle about the pivot point (70) of the support member. A supporting roller (108), cooperates with the support member to support the rear wheel. A flywheel (116) and variable load means (112) are connected to the roller to simulate the inertia and variable load experienced during the riding of a bicycle. When a rider of a bicycle shifts his weight forward the front fork support (42) bends and the rear tire of the bicycle pivots toward the roller to maintain frictional contact between the tire and roller. Frictional losses are determined and the variable load means compensates for the losses, and compensation is made for the inefficiency of the variable load means. The heart rate is monitored and the load is controlled to maintain the heart rate within predetermined limits.



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# BICYCLE RACING TRAINING APPARATUS

## Background of the Invention

This invention generally relates to a bicycle-type stationary exercise apparatus used with load control devices, display devices, and heart monitoring devices. The invention is particularly directed to an apparatus for use with a multi-speed bicycle, and is especially suited to train for bicycle races.

## Field of the Invention

A number of present-day gymnasiums and exercise clubs have stationary bicycle-type apparatus, whereby a person can pedal a simulated bicycle as a form of exercise. Typically, the bicycle pedals are connected to a frictional device or other load in a way such that the amount of resistance can be adjusted by the person riding the bicycle. Typical examples of this type of stationary bicycle are shown in U.S. Patent Nos. 4,358,105 (the "Lifecycle'") and 4,613,129.

Other exercise devices are adapted so that a conventional bicycle can be mounted to an apparatus which supports the bicycle so that the rear wheel of the bicycle can rotate against a frictional load. These types of devices fall into several general categories, the first of which connects both the front axle and the bottom bracket of the bicycle to a frame in order to support the bicycle. The rear wheel drives against a roller which, in turn, is connected to a loading mechanism. One example of such a device is shown in U.S. Patent No. 4,441,705 to Brown, in which the rear wheel drives a flywheel and a variable resistance load.

A second type of apparatus used with a conventional bicycle supports the rear wheel, either on a pair of rollers or by a fixed support at the rear axle. For example, U.S. Patent No. 4,596,386 to Sackl attaches to the rear axle to support the axle at a fixed distance from a pair of rollers. U.S. Patent No. 3,903,613 to Bisberg

supports the front wheel of the bicycle, while the rear wheel rests on a pair of rollers.

Each of the above types of devices has numerous drawbacks for use as an exercise device, and as use for a training device for bicycle racing. The stationary, simulated bicycles, like the "Lifecycle", do not provide a realistic pedal resistance simulating that obtained from riding a real bicycle; they do not adequately simulate inertia, wind resistance, terrain variations, and rolling resistance. Further, this type of stationary bicycle does not realistically simulate the body position or the feel of riding a bicycle, which is not surprising because a standard bicycle frame is not even used.

The devices using a bottom bracket support allow the use of a real bicycle frame, but fail to provide a realistic resistance and ride simulation. This type of equipment usually has one roller contacting the rear wheel.

The devices using a roller or rollers to support the rear wheel have stability and slippage problems. If the roller is behind the rear axle, the roller must be long since the wheel wobbles and moves sideways as it attempts to constantly "fall off" the roller. If the roller is in front of the axle, the wheel stays centered, but does not maintain adequate contact during periods of maximum torque on the rear wheel. In both cases, if a realistic resistance is applied, the rear tire slips on the roller.

For example, during some performance periods, the bicycle rider is not on the saddle, but is leaning over the handlebars and essentially standing on the pedals. As the weight of the rider shifts forward, the force on the rear wheel decreases and the weight on the front wheel increases, causing slipping of the rear wheel. Further, in this position with a bike on a bottom bracket support, the bicycle pivots about the bottom bracket, effectively removing the rear wheel from contact with the supporting roller or rollers. Thus, just when the maximum resistance

is needed to prevent slipping at the rear wheel, the rear wheel is at a minimum friction contact with the resistance rollers and slips.

5 The rear wheel can be preloaded against the support roller(s), but the preload device duly constrains the rear wheel so as to ruin the realism of the ride, and also destroys the realism of the simulated resistance when the rider is sitting in the saddle or bicycle seat, pedalling at a slower speed. Further, the bottom bracket holds the  
10 frame too rigid, destroying the realism of the ride as in real life, the frame flexes on the wheels.

The devices which use a pair of support rollers on the rear wheel not only tend to be bulky, but require complicated resistance mechanisms on both rollers in an  
15 attempt to achieve an appropriate resistance to the rear wheel rotation. Further, they do not simulate the feel of a real ride and may require a different balance and training to be able to remain upright while riding if the front wheel is also supported on a roller, as in the patent  
20 to Cassini, et al., No. 4,580,983. For example, if the front fork is fixed or supported, with two rollers on the rear wheel, the rear wheel wobbles and moves while the front is stable. In real life, the rear wheel is stable while the front wheel wobbles or moves. The use of two  
25 rollers still does not prevent slipping when the rider comes out of the saddle and leans over the handlebars to exert the maximum force on the pedals. The shift in the rider's weight still causes slippage between the rear wheel and the rollers.

30 There is thus a need for a device which provides a realistic ride on a bicycle and a realistic resistance, especially so that slippage does not occur when the rider is standing on the pedals to obtain maximum power. Further, there is a need to make such a device portable,  
35 especially one which can be used with an individual's own bicycle to provide the maximum realism for training

purposes.

Another aspect of this invention is the realistic simulation of the ride and load resistance experienced when riding a bicycle. The load variables can include wind resistance, whether the rider is going uphill or downhill, the inertia of the rider and bicycle, the friction inherent in the bicycle itself, and the frictional resistance between the bicycle tires and the riding surface.

Previous attempts to accurately replicate these various load effects have all had their drawbacks. For example, the effect of wind resistance has been simulated by rotating fan blades which are mechanically coupled to the rotational speed of the bicycle wheel. While the rotating fan blades can provide a force that increases as the square of the rotational speed of the fan blades, these fans are noisy, inaccurate, not readily adjustable, and cannot be adjusted to account for a variation in wind resistance that will occur with riders of different size and weight.

Similarly, prior devices have attempted to simulate the amount of load to be applied by either a mechanical or electronic brake system. A typical mechanical brake involves a friction belt that wraps around a moving surface to cause a frictional drag on that rotating surface depending upon the tension in the belt. These mechanical systems, however, cannot be accurately calibrated, have a slow response time, and are subject to load variations over time as the elements of the mechanical system go out of adjustment and alignment. The mechanical systems thus have poor repeatability, high variations in drag, and are difficult or impossible to accurately calibrate to a given load.

The electronic braking systems have advantages over the mechanical systems, but the accuracy of the simulated ride depends upon several factors, including how accurately the system can be calibrated, and the realism of the

program with which the electronic brake is varied. An example of variations in the simulation accuracy would be the wind resistance. A fan blade may simulate a load that varies with the speed of the bicycle wheel, but it cannot  
5 simulate the load resistance that varies with the size and the weight of the rider, or the wind load variation that occurs from riding at the front of a pack, or in the middle of a pack of other bicycle riders. Thus, there is a need for a more realistic simulation of load variability, and  
10 especially the wind load variability.

Both electronic and mechanical braking systems are effective only if they are accurately calibrated, and if that calibration is maintained throughout the load simulation. Electronic systems have previously been  
15 calibrated by several methods, including the use of strain gauges, which are accurate, but very expensive and cumbersome to implement. Some electronic and mechanical systems will attempt to measure the system power output by the use of a device such as a generator, and then assume a  
20 constant system efficiency and friction in order to calibrate the system. This calibration system cannot accurately predict the frictional losses in the system or any variations in the friction or loads exerted on the bicycle and rider. This type of calibration system also  
25 has no absolute reference and is therefore difficult to use in predicting performance under variable conditions.

One final method of calibration is to select an absolute reference and measure system variations against that reference. This type of approach requires that the  
30 initial reference be accurately determined, that the reference not vary in real life under different load conditions, and that the reference can be used to accurately monitor and calibrate the various aspects of the system performance. One example of this type of system is  
35 an electronic brake which assumes that a specific voltage change will result in a known load variation. Several

defects with this specific example are that the voltage and load relationship are difficult to predict and maintain over various temperatures and times, and that there is not a consistently accurate correlation between the voltage applied, and the load that the rider would realistically expect to experience in riding a real bicycle.

There is thus the need for a realistic way to calibrate the exercise system. There is a need for a realistic way to vary the loads in that exercise system so as to more accurately simulate the real life loads experience by a bicycle rider.

Yet another aspect of this invention is the ability to simulate realistic load conditions. United States Patent No. 4,441,705 uses fans attached to a bicycle wheel to simulate wind load, while Patent No. 4,542,897 to Melton shows a simulated competitor traveling at a predetermined speed. However, nothing in the prior art discloses varying the wind force according to the position of a racer with respect to one or more simulated riders. There is thus a need for a device which can simulate the race effect of varying the wind resistance depending on the position of the person exercising on the apparatus, with respect to a simulated rider.

Yet another aspect of this invention deals with the user's heart rate while exercising, which increases as the exercise progresses. To get the maximum benefit from the exercise, the heart rate should be within certain limits for a period of time. If the heart rate is too great, however, it is not productive, and may be damaging to the rider.

Prior devices, such as United States Patent No. 3,767,195 to Delick, provide visual indicators to indicate an upper limit for the heart rate by flashing a visual indicator when the upper limit was reached. The rider determined how much, if at all, to decrease the exercise level in order to lower the heart rate.

There is thus a need for a device which monitors the user's heart rate and adjusts the applied load in order to maintain that heart rate, or to prevent exceeding maximum heart rate limits. Desirably, the device should provide optimum heart rates if the user does not know such information.

#### Summary of the Invention

An apparatus is provided which supports a rear wheel and tire of a bicycle so that a forward shift in the rider's weight causes the rear tire of the bicycle to maintain frictional contact with a roller in order to prevent slippage. The roller is rotatably mounted about a first axis substantially parallel to a rear axle of a bicycle connected to the apparatus. The rear tire is constrained to move in a predetermined manner toward the roller. Preferably, the rear axle of the bicycle is supported on opposite ends of the axle shaft by axle clamps which are adjustably positioned on a rear axle support member. The support members constrain the rear axle to move along a predefined path which extends generally toward the roller. An arcuate path is preferred.

Preferably, the rear axle support means comprises a pair of members, each pivoted at one end about a pivot axis substantially parallel to the rotational axis of the rear wheel and tire. This pivot axis is preferably on the horizontally opposite side of the rear axle of the bicycle, as is the roller's rotational axis. The rear axle clamps can be adjustably positioned to accommodate different sizes of bicycles.

A variable load means, such as a motor, and preferably an alternator, and an inertial means, such as a flywheel, are connected to the roller and are preferably on a common shaft. The variable load and inertial loads exerted on the roller are transferred, via frictional contact with the rear tire, to the bicycle and its rider to simulate the momentum and load experienced during the actual riding of a

bicycle. Such loads would include wind resistance, terrain variations, rolling resistance, and the inertia of the bike and rider.

While the roller and support member can be used alone  
5 to support the bicycle, it is preferred that the front fork of the bicycle is mounted to a front fork support tube by use of a fork mounting bracket. Preferably the front fork support tube is such that it provides a realistic flexibility to simulate a realistic ride. The fork  
10 mounting bracket is positionally adjustable to accommodate different sizes of bicycles. The mounting bracket can flex to simulate real life flexing of the fork and front wheel. By repositioning the mounting bracket relative to the front fork, the elevation of the attached bicycle frame can be  
15 changed to tilt slightly upward from a level orientation.

Preferably, the front fork support tube is connected to the same structure that supports the roller and rear axle support mount. Thus, a shift in the weight of the rider off of a bicycle seat toward the front fork will  
20 cause the front fork support tube to bend and cause the rear axle support mount to rotate the rear bicycle tire toward the roller so as to prevent slippage between the roller and rear tire.

The front fork support tube also supports a display  
25 which is in electronic communication with the roller and alternator so that data, such as the bicycle speed, can be displayed for viewing by the rider.

There is thus advantageously provided a means for supporting a bicycle so as to simulate a realistic ride on  
30 that bicycle while preventing slippage of the rear wheel of the bicycle during periods of maximum force on the pedals. The realistic ride includes the feel of the load on the rear tire, as well as the flexibility of the bicycle.

The exercise apparatus can be collapsed into a  
35 smaller, portable configuration for portability and for storage. The front fork support tube contains hinges which

allow the tube to be folded into an adjacent relationship with the remainder of the apparatus. A releasable hinge adjacent the display unit, and a second releasable hinge located above the fork tube mount bracket, allows the display unit to be folded against the front fork support tube. The hinge at the bottom of the front fork support tube allows that tube, along with the display unit and its support members, to be folded into a position adjacent the roller. The pivot axes, about which the rear axle support members pivot, are positioned so that the rear axle support members can be folded into a position adjacent the roller. Wheels are provided on the end of the frame, adjacent the heavy flywheel and alternator, to allow easy movement of the portable package. There is thus provided a hinging means by which the apparatus can be folded into an adjacent relationship to present a smaller configuration which is much more portable than the operational configuration of the apparatus.

The apparatus is preferably calibrated to accurately produce the intended loads. One way to do this is to determine and compensate for the frictional losses in the apparatus when a bicycle is mounted on the apparatus. The steps for such a calibration sequence comprise: rotating a wheel in an exercising device until the wheel attains at least a first predetermined rotational velocity; allowing the wheel to coast down to a second predetermined rotational velocity during which coasting period the loading device is not exerting loads on the wheel other than inherent frictional loads; sensing and recording the time and rotational velocity at periodic intervals as the wheel coasts down from the first velocity to the second velocity; determining the rotational mass moment of inertia of any components of the exercise device that rotate because the wheel rotates; performing a linear regression analysis on the recorded velocities and times to determine the deceleration of the wheel and rotating components as a

function of velocity; and deriving the frictional load from rotation of the wheel and the rotating components of the exercise device from the formula Frictional torque equals the Mass Inertia times the Angular deceleration. An  
5 additional step would comprise computing the power required to overcome the frictional load from the formula: Power equals Mass moment times angular velocity.

The inefficiency of the loading device (which is preferably an alternator) is compensated for by the steps  
10 comprising: determining the efficiency of the loading device; determining the power output of the loading device by comparing the efficiency of the loading device with a second loading device for which the power output is known; and adjusting the loading device to account for the  
15 frictional losses and the efficiency of the loading device. Preferably, the efficiency is determined by performing a linear regression analysis to determine the power dissipated by the loading device at a predetermined speed, and by performing a linear regression analysis to determine  
20 the power which the loading device applies to the wheel.

When the loading device comprises an electrical device which exerts a load on the wheel where the load can be varied by varying the voltage applied to the loading device, the power dissipated is determined by the steps  
25 comprising: rotating the wheel until the wheel attains at least a third predetermined rotational velocity; allowing the wheel to decelerate to a fourth predetermined rotational velocity; applying a constant decelerating force from the electrical device in order to further  
30 decelerate the wheel as it decelerates from the third to the fourth velocities; sensing and recording the rotational velocity of the wheel and the voltage output by the electrical device at periodic intervals of time as the wheel decelerates from the third velocity to the forth  
35 velocity; performing a linear regression analysis on the recorded wheel velocity and the square of the voltage from

the coast down between the third and fourth velocities to determine the deceleration of the wheel and rotating components as a function of velocity; and wherein the power output by the loading device is further determined by the step comprising: performing a linear regression analysis on the velocity and on the deceleration times the velocity from the coast down between the third and fourth velocities in order to obtain linear regression constants for use in determining the power applied.

When the calibration steps are implemented by the above described exercise apparatus, the above apparatus further comprises variable load-applying means communicating with the roller for applying variable loads to the roller to simulate variations in the load encountered during actual riding of a bicycle; and calibration means for determining the friction retarding the wheel from rotating so the variable load-applying means can compensate for the friction. Preferably the calibrating means further comprises means for determining the efficiency of the variable load-applying means so the load-applying means can compensate for the inefficiencies of the load-applying means.

By accounting for the friction in the apparatus, and the inefficiencies of the loading devices, a more accurate load can be applied resulting in a more realistic ride simulation.

Another feature of this invention is a device and method to control the heart rate of a person exercising on the exercise apparatus. The heart rate controlling device takes the form of a decreased heart rate means operating when a person's heart rate is below a predetermined lower limit in order to increase the heart rate. The decreased heart rate means determines whether the loads exerted by the variable load means just increased and if so whether the heart rate has been at an increased rate for a predetermined period of time, with the decreased heart rate

means causing the variable load means to increase the load if the load is below a predetermined maximum value.

An increased heart rate shutdown means operates when a person's heart rate is more than a predetermined amount  
5 above the upper limit, to substantially decrease the load exerted by the variable load means. There is also an increased heart rate means that operates when the person's heart rate is above a predetermined limit in order to decrease the heart rate. The increased heart rate means  
10 determines whether the load exerted by the variable load means just increased, and if the load has been at an increased level for a predetermined time, the increased heart rate means causes the variable load means to increase the load. The increased heart rate means decreases the  
15 load exerted by the variable load means if the load has not just decreased and if the load is not below a predetermined value.

A means for monitoring the heart rate of the person exercising, and communicating that heart rate to the  
20 increased and decreased heart rate means, and to the increased heart rate shutdown means is also provided. A display screen communicates information on the loads and heart rate to the person exercising. If the person exercising does not know the appropriate limits to limit  
25 the load means, then the person inputs his or her age and sex, and the limits are determined by a computer.

The steps of the method by which the heart rate of the person exercising is controlled comprise: exercising by use of an exercise device so as to increase the heart rate  
30 of the person; varying the load which the exercise device exerts on the person to vary the heart rate of the person; sensing the heart rate of the person during the exercise; increasing the load by a predetermined amount when the person's heart rate is below a first predetermined value,  
35 with the increasing step comprising the further steps of: determining whether the variable load applied by the

exercise device on the person has just increased, determining whether the variable load has been unchanged for a first predetermined period of time, determining whether the load is below a first predetermined load value, and increasing the variable load by a predetermined amount when the load has not been changed during the first predetermined period of time and when the load is below the first predetermined load value. Additional steps comprise: decreasing the load by a predetermined amount when the person's heart rate is above a second predetermined value, the decreasing step comprising the steps of: determining whether the heart rate is above a third predetermined heart rate value, substantially decreasing the variable load while the heart rate is above the third predetermined load value, determining whether the variable load has just decreased, determining whether the variable load has been unchanged for a second predetermined period of time, determining whether the variable load has reached a second predetermined load value, and decreasing the variable load when the load has not been decreased for the second predetermined period of time and when the variable load has not yet reached the second predetermined load value.

An additional step on this method would be visually displaying messages to the person exercising, regarding either the load exerted by the person in response to the variable load, or to the person's heart rate. The imputing of data on the rider's age and sex, and the calculation of appropriate values or limits on heart rate would be yet another step of this method. Combining the heart controlling method and apparatus with the various variations on the bicycle support provides a realistic ride simulation. As described below, calibrating the friction in the exercise device, and in the load applying device further enhance the accuracy of the control on the load affecting the heart rate. Also as described below, combining the various race simulations provides an

advantageous way to train for races without over stressing the physical abilities of the rider. There is thus advantageously provided a means to adjust the load to maintain the user's heart rate within predefined limits, so as to provide a maximum of exercise and training, while automatically monitoring the user's heart rate to prevent over taxing the user.

There is also provided a method and apparatus for realistically simulating the loads experienced during a bicycle race. The race simulation apparatus comprises a stationary bicycle having a rear wheel that can be pedaled; means for selecting the performance ability of a group of simulated racers and simulating the race performance of the selected group of riders; input means connected to the rear bicycle wheel for determining the performance of a person pedaling the bicycle relative to the performance of the simulated racers; display means for displaying the position of the racer with respect to the simulated racers; and variable load means for exerting a variable load on the rear wheel to simulate the loads experienced during racing; and means for varying the load on the bicycle wheel depending on the position of the racer with respect to the group of racers. Preferably the above devices comprise the apparatus previously described above in greater detail.

Preferably the apparatus causes the variable load means to exert an increased load on the wheel to simulate a variable wind load when the racer leaves the group of simulated racers.. Further, the preferred apparatus further comprises means for causing the speed of the group of riders to vary randomly during a simulated race.

To simulate various races of selectable difficulty, there is provided a selection means for selecting a performance level of at least one simulated competitor; load calculation means for determining the load exerted by the load-applying means, based on the selected performance level; load sensing means for sensing the load exerted by a

rider to overcome the load applied by the load-applying means; means for displaying the performance of a rider relative to the simulated competitors; and means for varying the load exerted by the load-applying means depending on the position of a rider relative to the position of the simulated competitors. As a further variation, the display means further comprises means for displaying the elevation of the selected course, the position of a rider on the preselected course, the position of the rider relative to the simulated competitors, and the total elapsed time the instantaneous speed of the rider, distance traveled, heart rate, and cadence.

Preferably the load applying means takes the form of an electrical load-applying device communicating with a roller for applying variable forces to the roller to simulate the variations in load encountered during actual riding of a bicycle when a rear wheel of a bicycle is frictionally engaged with the roller and has a rear axle supported by the support member, the load-applying device also detecting the power exerted by a rider to overcome the applied load.

The various operations are preferably controlled by a computer controlling the load applied by the load-applying means, the computer having an input device by which a person can select a desired level of competition and the corresponding loads which are exerted by the load-applying device, the computer being programmed to determine and display on the visual display unit the performance of at least one simulated rider of the selected competition level, the computer being programmed to determine and display the position of a rider relative to the position of the simulated riders from the power exerted by the rider and simulated riders, the computer varying the load exerted by the load-applying device depending on the relative position of the rider and simulated riders to simulate wind load. The computer varies the performance of the simulated

competitor randomly within the selected level of competition.

The steps in the sequence implemented by the apparatus comprise: applying loads to the rear wheel by an electrical device in order to simulate various riding conditions and situations; applying loads to the rear wheel by a flywheel in order to simulate inertial loads; selecting a race course and the level of difficulty for the competition in the race; determining the loads to be applied to the rear wheel based on the selected level of difficulty for the selected race course; monitoring the performance of a rider pedaling the bicycle with the loads exerted on the rear wheel of the bicycle; displaying the position of the rider relative to at least one simulated rider; and varying the loads on the rider depending on the position of the rider relative to the simulated riders.

Further variations in the sequence comprise randomly varying the performance of the simulated riders during the course of the race; calibrating the electrical device to determine the friction in the exercise device so the electrical device can be adjusted to compensate for the friction loads; determining the efficiency of the electrical device; determining the power output of the electrical device by comparing the efficiency of the electrical device with a second electrical device for which the power output is known; and adjusting the electrical device to account for the frictional losses and the efficiency of the electrical device.

There is thus advantageously provided an apparatus and method not only for simulating the real "feel" of riding a bicycle, but for realistically simulating the loads experienced by riding that bicycle, even accounting for friction and inefficiencies in the apparatus and bicycle. The ability to simulate the environmental loads experienced during races, and to simulate competitors of selectable capability, provides not only a challenge, but a valuable

training tool and method. The ability to account for wind loads as a function of the rider's position within a pack provides further realism. The random variation of pack performance during the simulated race allows a rider to experience various strategies of jockeying for position. There is thus provided not only a more realistic and entertaining exercise device, but a device and method highly suitable for training for competitive races.

#### Brief Description of the Drawings

The present invention can be more readily understood when reference is made to the accompanying drawings in which:

Fig. 1 is a perspective view of this invention with a bicycle connected to it.

Fig. 2 is a perspective view of this invention with the side covering removed.

Fig. 3 is an exploded perspective of the rear axle clamp, its support, and the motor and flywheel.

Fig. 4 is a perspective view of a rear axle clamp.

Fig. 5 is an exploded perspective of a slidable hinge used on the front fork tube.

Fig. 6 is a perspective view of the assembled hinge shown in Fig. 5.

Fig. 7 is a perspective view of the front fork mounting structure and an adjacent hinge.

Fig. 8 is a perspective view of the invention with its support members folded into adjacent relationship to form a more compact, portable structure.

Fig. 9 is a perspective view of a segment of the invention showing wheels on the structure.

Fig. 10 is a side view of the folded and collapsed structure of Fig. 8.

Fig. 11 is a flow chart of a calibration sequence.

Fig. 12 is a plan view of the display unit as seen from a person exercising on a bicycle placed on the support apparatus shown in Fig.'s 1 - 10.

Fig. 13 is a flow chart of a power calibration sequence.

Fig. 14 is a plan view of a display window of the display unit as shown in Fig. 12.

5 Fig. 15 is a flow chart of a race simulation mode where wind load is taken into account;

Fig. 16 is a flow chart of a sequence to maintain a rider's heart rate within predetermined limits by varying the load on the exercise apparatus.

#### 10 Description of the Preferred Embodiment

Referring to Fig. 1, there is shown a portion of a multi-speed bicycle having a frame 10 with a rear axle 12 on which is mounted a rear wheel 14 and a rear tire 16. The frame 10 also contains a bottom bracket 18 to which a  
15 crank set and pair of pedals 20 are rotatably mounted. A seat 22, handlebars 24 and a rotatably mounted fork 26, are also connected to the frame 10 in a manner known in the art and not described in detail herein.

Referring to Figs. 1 and 2, a portion of the bicycle  
20 is connected to a means for supporting the bike, such as support frame 28. The support frame 28 comprises a bottom member 30 which is approximately 27 inches long, and of a square tubular metal, approximately 1.5 inches per side, with a wall thickness of .109 inches.

25 At one end of the bottom member 30 are two rear legs 32 and 34 (Fig. 9) which extend in opposite directions generally perpendicular to the longitudinal axis of bottom member 30. Preferably, the legs 32 and 34 are opposite ends of a continuous member. At the opposite end of bottom  
30 member 30, there are connected two front legs 36 and 38 which extend in generally opposing directions from the bottom member 30. The front legs 36 and 38 extend at an angle of approximately 67 degrees from the longitudinal axis of the bottom member 30 so as to angle away from the  
35 rear legs 32 and 34. The same angle, measured from the perpendicular, is 23 degrees. The legs 32 and 34 are all

of tubular metal construction having a generally rectangular cross-section approximately .75 inch x 1.5 inches, with a wall thickness of about .120 inches. The legs 36 and 38 are also tubular of construction having a rectangular cross section of about 1 inch x 2 inches, and a wall thickness of .120 inches.

The bottom member 30 and legs 32, 34, 36 and 38 lie generally in a plane so as to provide a stable support for the bike frame 10 and rider. Support feet 40 are located at the outermost ends of the legs 32-38 and are intended to rest against a floor.

A means for supporting and mounting the front fork 26 of a bicycle is provided which simulates the movement, and flexibility of a front wheel of a bicycle. Thus, fork tube 42 is connected to the juncture of bottom member 30 and front legs 36 and 38. The fork tube 42 extends out of the plane of the legs 32-38 at an angle of approximately 53 degrees from that plane, and in a direction away from the rear legs 32 and 34. The fork tube 42 also extends along a plane passing through the longitudinal axis of the bottom member 30 and oriented substantially perpendicular to the plane formed by the legs 32-38. The fork tube 42 is of a tubular metal construction, using 1.5-inch square tubing with a wall thickness of .109 inch.

Referring to Figs. 2 and 7, a fork mount 44 is connected to the side of the fork tube 42 facing the rear legs 32-34. Referring to Fig. 7, the fork mount 44 comprises a generally rectangular strip of metal 1.25 inches wide by 6.25 inches long and .135 inch thick. Two elongated slots 46 and 48 are located along the longitudinal axis of fork mount 44. Preferably, the slots 46 and 48 are approximately .34 inch wide by 1.85 inches long, and begin about .33 inch from the ends of fork mount 44.

Removable fasteners 50 and 52 extend through the slots 46 and 48 into corresponding apertures (not shown) in the

fork tube 42 in order to connect the fork mount 44 to the fork tube 42. Preferably, the fasteners 50 and 52 take the form of threaded bolts. By loosening the fasteners 50 and 52, the slots 46 and 48 allow the fork mount 44 to be slid  
5 along the length of the slots 46 and 48, thereby permitting repositioning of the fork mount 44 relative to the length of the fork tube 42. The fasteners 50 and 52 can be removed so the fork mount 44 can be rotated 180 degrees in the plane in which it is mounted, and then re-secured. The  
10 fasteners 50 and 52 allow the fork mount 44 to flex, and help simulate a realistic movement of a bicycle attached to the frame 28 via the fork mount 44.

A fork mounting tube 54 (see also Figs. 1 and 2) is connected to the fork mount 44. The fork mounting tube 54  
15 comprises a metal tube approximately 3.5 inches long, with an outer diameter of about .75 inch, and an inner diameter of about .38 inch. The interior ends of the fork mounting tube 54 can be threaded. The fork mounting tube 54 is located with its longitudinal axis perpendicular to the  
20 longitudinal axis of the fork mount 44 and the slots 46 and 48. The fork mounting tube 54 is not located at the center of fork mount 44, but is offset approximately 1/4-inch so that it is closer to the end of slot 48 than it is to the end of slot 46.

25 The fork mount 44 provides an adjustable attachment means for connecting the front fork of a bike to the fork tube 42. The adjustable feature is used to accommodate different sizes of bicycle frames and, as described later, to alter the elevation of the bike frame 10 by  
30 repositioning the fork mount 44 on the fork tube 42.

Referring to Figs. 2 and 3, connected to the rear leg 32 is an inner support plate 56 and an outer support plate 58. The support plates 56 and 58 are substantially parallel plates located in planes substantially parallel to  
35 a plane passing through the longitudinal axis of bottom member 30, but substantially perpendicular to the plane in

which the legs 32, 34, 36 and 38 are located. The inner support plate 56 is closer to the bottom member 30 than is outer plate 58. The support plates 56 and 58 can be made out of .134 inch thick steel.

5        An inner support plate 60, which generally corresponds to inner support plate 56, is connected in an analogous manner and orientation to rear leg 34. Similarly, an outer support plate 62, which corresponds to outer support plate 58, is connected in an analogous manner and orientation to  
10      the rear leg 34.

When a rear wheel 14 and rear tire 16 (Fig. 1) are connected to the apparatus, the rear tire 16 is constrained to move in a predetermined manner. Preferably, a rear axle support member constrains the rear axle 12 of a bicycle to  
15      move along a predetermined path. While the support member could be a U-shaped member, preferably, the support member is a pair of axle tubes 64 and 66. The first axle tube 64 is rotatably mounted between the support plates 56 and 58, and a second axle tube 66 is rotatably mounted between the  
20      support plates 60 and 62. The first and second axle tubes 64 and 66 are constructed and connected in an analogous manner, so only the first axle tube 64 will be described in detail.

Referring to Fig. 3, the first axle tube 64 is  
25      preferably a stiff or rigid member, which does not flex to any great extent, and can comprise a tubular metal bar having a rectangular cross-section approximately .75 inch thick and 1.5 inches wide, 12.5 inches long and about .12 inch thick. A rotatable mount 68 is connected at one end  
30      of first axle tube 64 to one of the 1.5-inch wide sides of axle tube 64. The rotatable mount 68 is shown as a cylindrical tube with an outside diameter of about 1 inch and an inside diameter of about .52 inch, and a length of about 4.7 inches which corresponds to the spacing between  
35      the support plates 56 and 58. The longitudinal axis of the rotatable mount 68 is perpendicular to the longitudinal

axis of the first axle tube 64.

The first axle tube 64 is mounted so that it can pivot in a plane substantially perpendicular to the plane in which the legs 32-38 are located, substantially parallel to the plane of the bottom member 30. This pivot axis is substantially parallel to the rotational axis of the rear wheel 14 and tire 16 connected to the axle tubes 64 and 66.

Pivoting action is achieved by passing a bolt 70 through a hole 72 in the outer support plate 58, through the inside of the rotatable mount 68, and through a corresponding hole (not shown) in inner support plate 56. A fastener 74, such as a threaded nut, is welded to the side of inner support plate 56 so that a threaded end on bolt 70 can be secured by the fastener 74 to prevent inadvertent removal of the bolt 70. The longitudinal axis of the bolt 70 is substantially parallel to the longitudinal axes of rear legs 32 and 34. The bolt 70 thus supports the first axle tube 64 and constrains the axle tube 64 to pivot about the longitudinal axis of bolt 70.

As previously stated, a second axle tube 66 is pivotally mounted and constrained to pivot about a bolt 70 in a similar manner as the first axle tube 64 with such bolts coaxially aligned. The axle tubes 64 and 66 are located adjacent the respective outer support plates 58 and 62. The inner sides of axle tubes 64 and 66 are about 11 inches apart. The first and second axle tubes 64 and 66 thus form movable support means which constrain the rear wheel 14 and tire 16 to move along a predetermined path.

As shown in Figs. 2 and 3, at the end of axle tubes 64 and 66 opposite the pivotally constrained end are axle clamps 76 and 106 which are connected to the axle tubes 64 and 66 by an axle clamp bracket 78. Referring to Fig. 4, the axle clamp 76 comprises a metal cylinder with a conical depression 77 in one end. A pair of opposing rectangular slots 79 extend partway down opposing sides of the axle clamp 76. In use, a conical-shaped nut or end of the

bicycle's rear axle 12 is seated in the conical cavity 77. The slots 79 accommodate D-rings that are used on the quick release skewers used with several bicycle models.

Referring to Fig. 3, the axle clamp bracket 78  
5 comprises a repositionable support plate 80 comprised of a strip of metal having an L-shaped cross-section .75 inch on the short side, 1.5 inches on the long side, 6 inches long and .120 inches thick. An elongated slot 82 runs along the longitudinal axis of the plate 80 for a length of about 3  
10 inches.

A bolt 84 has a threaded portion which extends through the slot 82 and through a hole (not shown) in axle tube 64. A fastener such as a threaded nut 86 can be removably connected with the threaded end of bolt 84 in order to  
15 releasably clamp the plate 80 to the axle tube 64. The plate 80 can be repositioned along the length of the axle tube 64 by loosening the bolt 84 and sliding the plate 80 along the length of slot 82, and then reclamping the bolt 84 and nut 86.

20 At the end of the plate 80, adjacent the unconstrained end of axle tube 64, is a clamp tube 88. The clamp tube 88 is a cylindrical tube having an outer diameter of about 7/8 inch, a threaded inside diameter of about 1/2 inch, and a length of about 1.5 inches. The tube 88 has its  
25 longitudinal axis substantially perpendicular to the longitudinal axis of axle tube 64 and substantially parallel to the longitudinal axis of bolt 70. A threaded shaft 90 threadingly engages the interior threads of tube 88. The axle clamp 76 is fastened at one end of shaft 90,  
30 with a knob 92 being fixed at the opposing end of shaft 90. By rotating the knob 92, the shaft 90 can be rotated so as to reposition the axle clamp 76.

A locking knob 93 is located intermediate to the knob 92 and the tube 88. The locking knob 93 is a knob having a  
35 threaded hole through the center, so the knob can be screwed along the length of threaded shaft 90. When the

axle clamp 76 is correctly positioned, the locking knob 93 is screwed against the end of tube 88 to provide a frictional lock, preventing axial movement of shaft 90 and axle clamp 76.

5       A second axle clamp 106 coaxially aligned with clamp 76 (Figs. 3 and 4) is connected to the unconstrained end of the second axle tube 66 in the same manner as axle clamp 76 is connected to the first axle tube 64. Thus, the details of the second axle clamp 106 and its supporting bracket  
10 will not be repeated, other than to note that one axle clamp is slightly longer, with a deeper slot 79, in order to accommodate a variety of designs for axles 12 as used on diverse bicycles.

Referring to Figs. 2 and 3, a rotatable means helps  
15 support the rear wheel 14 of a bicycle connected to the apparatus of this invention. A roller 108 is rotatably supported between the inner support plates 56 and 60. Preferably, the roller 108 is a cylindrical roller with a width of about 2.6 inches and an outer diameter of 2.5  
20 inches, made of aluminum. The roller 108 is rotatably mounted so that its longitudinal axis is substantially parallel with the longitudinal axis of bolt 70 and the pivot axis of first and second axle tubes 76 and 106, and with the rotational axis of a rear wheel 14 connected to  
25 the apparatus.

Referring to Fig. 1, preferably the support frame 28 connects to, and supports, the bike frame 10 at three locations. As shown best in Fig. 7, the fork 26 of bike frame 10 can be removably connected to the fork mount 44 by  
30 use of a quick-release skewer 110. The quick-release skewer 110 is commonly used on bicycles having a readily removable front wheel, and thus is known in the art and will not be described in detail. The ends of fork 26 fit over the fork mounting tube 54. The quick-release skewer  
35 110 is inserted through the fork 26 and the fork mounting tube 54, and then locked to secure the fork 26 to the fork

mount 44. Basically, the fork mount 44 is connected just as if it were the front wheel of a bike.

Referring to Fig. 1, the rear axle 12 of the bike frame 10 is supported by the first and second axle clamps 76 and 106. The conical apertures 77 (Fig. 4) in the axle clamps 76 and 106 fit over the opposite ends of the rear axle 12 so as to support axle 12 and bike frame 10. The rear axle 12 is constrained to move along an arcuate path about the rotational axes of first and second axle tubes 64 and 66, with the path being generally toward roller 108.

The tire 16 rests against the roller 108. Preferably, when viewed in a horizontal plane, the roller 108 is in front of the rear axle 12. The rear axle 12 is shown as being horizontally in front of the rotational axis about which the axle tubes 64 and 66 rotate. Thus, the axle 12 (about which rear wheel 14 rotates) is positioned, relative to a horizontal plane, between the roller 108 and the rotational axis about which axle tubes 64 and 66 rotate. Alternately phrased, if substantially parallel, vertical planes are passed through the rear axle 12, rotational axis of roller 108, and the rotational axes of axle tubes 64 and 66, then the vertical plane containing the rear axle 12 lies between the planes containing the rotational axes of roller 108 and axle tubes 64 and 66. Phrased yet another way, a substantially vertical plane through the rear axle 12, would result in the pivot axis of the rear axle tubes 64 and 66 and the roller 108, being located on opposite sides of that vertical plane.

It is believed preferable that the angle of the rear axle tubes 64 and 66, with respect to the vertical, be between 5-30 degrees. From this position, the tubes 64 and 66 will rotate from 1-4 degrees further during operation, depending on rider weight and strength, tire pressure, and the specific bike frame 10. When the bike frame 10 is that of a Schwinn Paramount having a 54 cm frame, and a 99 cm wheelbase, with 700C wheels, the angle is about 26.5

degrees, with the rear axle 12 being about 10.5 inches from the pivot points of axle tubes 64 and 66, and with the rear axle 12 being almost vertically above the rotational axis of roller 108. These dimensions are at the extreme end of dimensions for a short wheelbase racing bicycle.

If the axle 12 is positioned vertically above, or in front of (i.e. toward the handlebars 24) the roller 108, the invention will still function, but as the axle 12 is moved in front of the roller 108, then the performance is increasingly degraded, but it can function. If the rear axle 12 is positioned vertically above, or behind the pivot axis of bolts 70, the rear tire 16 will not be constrained to move into contact with the roller 108 and the apparatus will not satisfactorily function. The objective is to cause the rear tire 16 to move into contact with the roller 108 when the torque on the tire 16 increases, as when the rider leaves the saddle 22 and leans over the handlebars 26 to exert increased force on the pedals 20.

Preferably, the rotational axis of roller 108 is about 4.6 inches (horizontally) from the rotational axis of axle tubes 64 and 66, and about 5.1 inches (vertically) from the rotational axis of axle tubes 64 and 66. The fork mount 44, the axle clamps 76 and 106 (Fig. 2), and the roller 108 provide a three-point support for the bike frame 10 when the frame 10 is coupled to the support apparatus. As a rider pedals the bike via pedals 20, the rear wheel 14 and tire 16 frictionally engage the roller 108, causing roller 108 to rotate.

It is believed possible, although not preferred, to have only the axle clamps 76 and 106 support the bike frame 10, in which case the front fork tube 52 would be eliminated, and the bottom member 30 shortened, so a standard front wheel of a bicycle could be used to support the front fork 26. It is also believed possible, but not preferred, to support the front fork tube 42 separately

from the remainder of the frame 28, and to adjust the flexibility of the fork tube 42 to simulate the stiffness, and to allow the movement, of a normal front wheel of a bicycle.

5 Referring to Figs. 2 and 3, a variable load device, such as an electromagnetic apparatus like an alternator 112, powered by 110V AC, is connected to the roller 108. The alternator 112 is connected to the inside support plate 56 and is located between support plates 56 and 58. An  
10 alternator shaft 114 (Fig. 3) extends through a hole in the inner support plate 56 (Fig. 2). One end of the alternator shaft 114 (Fig. 3) is connected to the alternator 112, with the opposing end being connected to the roller 108, preferably by shrink-fitting the roller 108 onto the end of  
15 the alternator shaft 114.

By applying a variable amount of electrical power to the alternator 112, a variable and controllable amount of resistance can be applied to the roller 108, and thus to the tire 16 and the pedals 20 (Fig. 1). This variable load  
20 resistance can be used to simulate the resistance experienced by pedalling on different grades, downhill, flat or uphill. The load can simulate rolling resistance, wind resistance, terrain variations, and if properly programmed, can even simulate the inertia of the bicycle  
25 and rider. Thus, the alternator 112 communicates with the roller 108 to simulate a realistic bicycle ride.

Preferably, the inertia is simulated by inertia means, such as a flywheel 116, which is rotatably mounted between the support plates 60 and 62 (Fig. 2). The rotational axis  
30 of flywheel 116 coincides with the rotational axis of roller 108 and alternator 112. A specific flywheel could be designed for a given weight of a bicycle and rider, and a maximum speed. Space, safety and weight constraints must also be considered, however. A flywheel 116 found suitable  
35 for use is designed to rotate at a maximum speed of about 5000 r.p.m., for an equivalent bike speed of 40 miles per

hour for a 27 inch bicycle wheel. Such a flywheel weighs about 22 pounds, and when made of cast iron, can take the form of a rimmed circular disc 2 inches wide and 8 inches in diameter. The inertia of such a usable flywheel has  
5 been calculated to be  $0.05648 \text{ N} \cdot \text{m} \cdot \text{sec}^2$ .

The flywheel 116 communicates with roller 108 so rotation of the roller 108 rotates the flywheel 116. As shown, the flywheel 116 is mounted on a shaft 118 which extends through a hole in the inner support plate 60 to  
10 connect to the roller 108. Preferably, the roller 108 is shrink-fit onto one end of the flywheel shaft 118. Thus, the flywheel 116, roller 108 and alternator 112 are essentially on a common rotational shaft. The inertia means, such as flywheel 116, simulates the inertia of a  
15 moving bicycle and rider.

Referring to Figs 1 and 2, the fork tube 42 is about 21.5 inches long, and contains a hinged joint 124 which is best shown with reference to Figs. 5 and 6. At a point approximately 7.5 inches above the plane of the legs 32-38  
20 (Fig. 1), the fork tube 42 is cut at an angle such that there is a first end 126 and second end 128 which can be releasably placed in an abutting configuration. On the inside of fork tube 42 adjacent the first end 126, there is inserted a smaller, slidable tubular section 130 which is  
25 configured to just fit inside of the first end 126. On opposing sides of slidable tubular section 130 are located longitudinal slots 132. A fastener such as bolt 134 extends through opposing sides of fork tube 42 and through the slots 132 so as to captivate the slidable tubular  
30 section 130. Thus, the slidable tubular section 130 can be moved along the longitudinal axis of the fork tube 42 until the bolt 134 bottoms out against the ends of the slots 132.

A rotatable hinge 135 rotatably connects slidable tubular section 130, with a correspondingly sized tubular  
35 section 136. The tubular section 136 fits inside of, and is securely fastened to, the second end 128 of fork tube

42.

In operation, the tubular sections 130 and 136 fit on the inside of fork tube 42 and provide a structurally strong joint when the ends 126 and 128 are abutting. The sections 130 and 136 allow the first and second ends 126 and 128 to be separated by a force exerted along the longitudinal axis of fork tube 42. When the first and second ends 126 and 128 are separated, the hinge 135 allows the portion of the fork tube 42 containing the end 128 to be folded so as to collapse the support frame 28 into a more compact configuration (Figs. 8,10).

In order to ensure the integrity of the hinged joint 124 in the uncollapsed position, and to prevent inadvertent separation of the hinged joint 124, releasable fasteners 138 (Fig. 5) extend through the side walls of fork tube 42 and releasably fasten the slidable tubular section 130 into secure position. The fasteners 138 each comprise a threaded portion 140 extending from a knob 142. Each threaded portion 140 extends through an associated threaded aperture 144 in fork tube 42 so that the end of the threaded portion comes into contact with and binds against the slidable tubular section 130 so as to prevent movement of such sections within tube 42. The apertures 144 preferably are located in the corner of the fork tube 42.

The hinged joint 124, and the rotation of the axle tubes 64 and 66 (Figs. 8,10), thus provide collapsible joints by which a stable operational structure can be formed, but which can be collapsed or reconfigured to a configuration more suitable for storage or portability.

Referring to Fig. 1, a side cover 120 has one end connected to the support plates 56 (Fig. 2) and 58 with the opposing end connected to the front leg 36. A corresponding side plate 122 is connected between support plates 60 and 62 (Fig. 2), and front leg 38. The side covers 120 and 122 cover the flywheel 116 and alternator 112 (Fig. 2), and provide some stiffness and stability to

the support frame 28 as well. Because the support plates 56-62 (Fig. 2) are higher than the front legs 36 and 38, the side covers 120 and 122 slant downward at an angle. The side covers 120 and 122 must be sufficiently low so  
5 that a rider's heel will not hit the side plates when pedalling. In a similar manner, the axle tubes 64 and 66 must not be so long that they will be hit by the heel of a rider when pedalling.

The side plates 120 and 122 are removable (see Fig. 2)  
10 and comprise generally C-shaped structures preferably made out of sheet metal having a thickness of about .060 inches. The sides of the side plates 120 fit over the sides of the support plates 56 and 58 (Fig. 2), and the sides of the side plate 122 fit over the sides of the support plates 60  
15 and 62 (Fig. 2). The side plates 120 and 122 are spaced apart so that the bottom member 30 is visible between the side plates 120 and 122.

Referring to Figs. 1 and 2, a display tube 150 is connected to the upper end of fork tube 42. A display 152  
20 is in turn connected to the outer end of display tube 150. The display tube 150 is of the same general construction as fork tube 42, and is rotatably joined to fork tube 42 by rotatable joint 154. The joint 154 comprises a hinged member which uses one or more frictionally releasable  
25 devices to hold the joint stable when desired, or to release the joint to allow a rotation when desired. The releasable frictional device is shown as comprising a hinged joint, having a side through which a threaded fastener 156 extends to releasably lock the joint 154 by  
30 loosening or tightening the fastener 156, the friction in the joint 154 is increased or decreased, so as to lock the joint 154 into position or to allow it to rotate.

The end of display tube 150 is connected to display 152 by means of a repositionable and tiltable joint 157. A  
35 channel bracket 159, having a C-shaped cross section is fastened to the back side of the display 152, with the free

legs of the C-section extending outward from the display 152. Each of the free legs of channel bracket 159 has a slot 160, running along the length of the bracket 159. The display tube 150 fits within the channel bracket 159. A  
5 releasable fastener 162 has a shaft (not shown) that passes through slots 160 and through a hole (not shown) adjacent the outer end of display tube 150, and connects to a threaded knob (not shown). The fastener 162 and threaded knob cooperate to frictionally lock the end of the display  
10 tube 150 to the bracket 159, and thus to the display 152. The connection is releasable by loosening the fastener 162.

The slots 162 allow the display 152 to be positioned relative to the end of the display tube 150, and effectively provide a means for adjusting the height of the  
15 display 152. The display 152 can also be rotated about a loosened fastener 162 to adjust the angular orientation of display 152, and tightening the fastener 162 locks the display into position. There is thus provided a joint 157 that allows repositioning and tilting of the display 152.

20 The display 152 is in electrical communication with the alternator 112 so that various loads can be controlled from, and displayed by, the display 152. The electrical communication mean can comprise wires, which are known in the art and not described in detail, or shown herein.  
25 Thus, for example, a rider can input the resistance which is desired to be exerted by the alternator 112, and can monitor the speed at which the bike is being pedalled against that predetermined resistance.

Referring to Fig. 1, the operation of the invention  
30 will now be described. A person can take his or her own personal bicycle, remove the front wheel and mount it to the support frame 28. Many modern racing bikes have removable front wheels which facilitate this installation. The fork 26 of the bike frame 10 is attached to the fork  
35 mount 44 by use of a quick-release skewer 110. To accommodate for different sizes of bike frames 10, the fork

mount 44 can be releasably positioned by loosening fasteners 50 and 52 (Fig. 7), repositioning the fork mounting tube 54 and then refastening fasteners 50 and 52.

Referring to Fig. 7, as previously mentioned, the fork mounting tube 54 is asymmetrically located between the ends of the slots 46 and 48. By slidably positioning the fork mount 44, relative to the fork tube 42, it is possible to adjust the vertical elevation of the bike frame 10. Many riders find a slight uphill elevation to be more comfortable when riding a stationary bicycle.

Preferably the fasteners 50 and 52 are positioned at, and rest against the upper ends of the slots 46 and 48. If so positioned, the mount 44 bears against the fastener 50 and 52.

Since the mounting tube 54 is offset relative to the ends of slots 46 and 48, the mounting plate 44 can be rotated 180 degrees in plane to change the elevation of the mounting tube 54 (and the bike 10), while still allowing the fasteners 50 and 52 to bear against the ends of the slots 46 and 48.

Referring to Figs. 1 and 3, the tire 16 is placed on the roller 108. The first and second axle tubes 64 are then rotated so the first and second axle clamps 76 and 106 can engage opposite ends of rear axle 12. Turning knobs 92 (Fig. 3) allows the axle clamps 76 and 106 (Fig. 3) to be adjusted along the length of rear axle 12 so the ends of axle 12 can seat in the conical apertures 77. The threaded shaft 90 (Fig. 3) therefore provides an adjustable means for accommodating different axle lengths for positioning of the bicycle frame 10 between the first and second axle tubes 64 and 66. The ability of the first and second axle tubes 64 and 66 to rotate combine with the ability to reposition the axle clamp bracket 78 (Fig. 3) to accommodate a wide range of bike sizes.

Referring to Fig. 1, in operation, the mounting of the fork 26 to the fork mount 44 provides a flexible mount that

reduces stresses and fatigue failure problems with the fork 26. The flexibility is provided by the fact that the fork mount 44 can effectively pivot or flexibly rock about a line passing through the fasteners 50 and 52 (Fig. 7), even when those fasteners are tightly secured. The fork mount 44 and the fasteners 50 and 52 bend to allow this flexibility. The flexibility simulates the lateral flexibility of a front wheel of a bicycle to further simulate a realistic ride.

10 A rider can reposition the fork mount 44 to provide for a level orientation of bike frame 10, or a slightly elevated orientation as previously described. When the rider sits on the seat 22 and exerts force on the pedals 20, the weight of the bicycle and rider force the tire 16 against the roller 108 to provide a frictional drive of the roller 108. The flywheel 116 (Fig. 2) simulates the inertia of the rider and bicycle, while the variable resistance exerted by alternator 112 (Fig. 2) can be used to simulate a ride on a level surface, a downgrade, an uphill grade or any combination of variable grades.

In use, however, the rider does not always stay seated in the seat or saddle 22, but at times of increased power, rises off of the saddle, leans over the handlebars 24 and exerts all of the rider's weight on the pedals 20. Thus, while more of the rider's weight is on the rear wheel when the rider is seated in the saddle 22, the rider's weight is shifted towards the front wheel when the rider rises out of the seat 22 and exerts increased force and weight on the pedals 20.

30 As the weight of the rider shifts toward the fork 26, the frame 28 operates to maintain, and can actually increase the friction between the tire 16 and the roller 108 in order to prevent slippage. The first and second axle tubes 64 and 66 constrain the rear axle 12 to move along a predefined, arcuate path such that a shift in the weight of the rider toward the fork 26 causes the axle 12,

and thus the tire 16, to move toward to the roller 108.

It is also believed that the relative stiffness between the bike frame 10 with respect to the frame 28 is such that a movement of the rider toward the fork 26 causes the fork tube 42 to bend or flex forward and downward and, since the bike frame 10 is connected to the fork tube 42, the bike frame 10 causes the constrained axle 12 to rotate toward the roller 108. It is believed preferable that the stiffness of the bike frame 10, including the fork 26, be greater than the stiffness of the support frame 30, which includes fork tube 42, and the axle tubes 64 and 66.

While the exact theoretical basis may not be precisely known, the practical effect is apparent. With the rider seated in the seat 22, the roller 108 and support axles 64 and 66 support the weight that is normally on the rear so there is no excessive friction between the roller 108 and the rear tire 16. As the weight of the rider shifts forward from the seat 22 toward the fork 26, the tire 16 does not slip against the roller 108. The fork tube 42 and constrained rear axle 12 move in unison albeit perhaps in different amounts, with the amount of motion varying with the amount of force exerted on the pedals 20, and the position of the rider relative to the front fork 26. Further, a rider using toe clips and straps on the pedals 20, appears to exert a forward force on the pedals 20 which also causes the fork tube 42 and constrained rear axle 12, to move in unison.

Such was not the case with prior art devices using single or double support rollers. For example, many prior devices used a support that connected to the bottom bracket 18 (Fig. 1). As the weight of the rider shifted forward, the bike pivoted about the support connected to the bottom bracket 18, and the tire 16 moved out of contact with the prior art roller(s). Further, the mere shift in the rider's weight decreased the force on the rear wheel, and thus decreased the friction against the rollers. Thus, the

shift of the weight of the rider effectively decreased the friction between the tire and the roller, causing the roller to slip just when the maximum amount of power was being transferred to the tire.

5        There is thus advantageously provided a means of increasing the friction between the tire 16 and the roller 108 during periods when large amounts of power are being applied to the pedals 20. There is thus also advantageously provided a means of using the location of  
10 the weight of the rider to prevent slippage between the tire 16 and the roller 108. There is also provided a means of using the flexibility of the frame 28 to prevent slippage and increase the friction between the tire 16 and roller 108.

15        Referring to Figs. 8 and 10, a further advantage of the present invention is that collapsible means are provided so the apparatus can be folded into a compact package to make it readily portable. As previously described, the first and second axle tubes are rotatable  
20 about the axis running along the length of bolt 70 (Fig. 3). By correctly positioning the rotational joint, the first and second axle tubes 64 and 66 can be folded into a more compact shape. Preferably, they can be folded adjacent the side covers 120 and 122.

25        The joints 124, 154 and 157 allow the display 152 to be folded adjacent the side covers 120 and 122. The fork tube 42 and the display tube 150 can fit into the space between the side covers 120 and 122. There is thus provided collapsible means which allow the apparatus to be  
30 folded into a more compact, portable configuration than the operational configuration of the apparatus.

Referring to Fig. 2, the heaviest portion of the invention is located at the support plates 56, 58, 60 and 62, which support the flywheel 116 and the alternator 112.  
35 Referring to Fig. 9, to increase the ease of portability, a pair of rotatable wheels 170 are mounted at the juncture of

the rear legs 32 and 34, opposite the joinder of the bottom member 30. When the invention is lifted so as to rotate about a line passing through the rear legs 32 and 34, the wheels 170 come in contact with the ground or floor so that  
5 the invention can be rolled without dragging the foot pads 40. The wheels 170 are not able to roll when the apparatus is in its operational position as shown in Figs. 1 and 2.

Referring to Figs. 8-10, preferably, the back surface of the covers 120 and 122 and the support plates 56-62  
10 (Fig. 2) are flat so that the invention can maintain a stable standing position on its end, in a vertical orientation as illustrated in Figs. 9 and 10.

As previously mentioned regarding Fig. 2, a variable load device such as the alternator 112 is connected so as  
15 to rotate in conjunction with the roller 108. As the armature of the alternator 108 rotates, current variations occur which can be used to indicate the rotational speed of the roller 108. The speed can be calculated by measuring the time between pulses from a diode on the alternator.  
20 There are six diode pulses for one revolution of the 2.5 inch diameter roller 108. The pulse data can be used to calculate both speed, and distance traveled. The alternator 112 is in electronic communication with the display unit 152 by means such as wires which are known in  
25 the art, and not described in detail herein. In practice, the alternator 112 provides two signals to the display unit 112, one for speed, and one for resistor voltage through an external power resistor 243.

The resistor voltage communicates with an analog to  
30 digital (A/D) converter in the display 152. The A/D converter is known in the art and is not described in detail herein. The A/D converter assigns a maximum value of 255 to the voltage, which corresponds to a voltage of 25 volts. A resolution of about 0.1 volts in the A/D converter  
35 has been found suitable.

Referring to Fig. 11, the display unit 152 contains a

computer 200 which monitors and/or calculates the rotational speed of the alternator 112 and the roller 108. The rotational speed of the roller 108 is related to the distance travelled, and the speed of the bicycle, which can  
5 be calculated by the computer 200. The computer 200 also controls the voltage to the alternator 112 by means of a digital to analog (DAC) converter, which adjusts the field current in the alternator 112.

The computer 200 also works in conjunction with a  
10 timer 202 which monitors various functions of the computer at predetermined intervals. The timer 202 works in conjunction with the computer 200 to calculate the absolute amount of friction in the exercising apparatus, and in the bicycle mounted on the exercise apparatus.

15 The flow chart of Fig. 11, taken in conjunction with Figs. 1 and 12, describes a calibration sequence in which the rider sits on the saddle 22 (Fig. 1) and presses a start button 204 on the display 152 (Fig. 12) in order to initiate the calibration sequence. Upon initiation, block  
20 206 (Fig. 11) instructs the system to warm up, which is preferably achieved by applying full field current to the alternator 112 for about 30 minutes, and then riding the bicycle for a few minutes to disperse the grease in the bearings. The warmup reduces the temperature effects on  
25 the system accuracy.

Block 208 initializes the digital to analog converter (DAC) to zero, which causes the alternator 112 (Fig. 2) to place no additional resistance load (other than inherent frictional loads) on the roller 108 (FIG. 2) or tire 16.  
30 Block 210 commands the display unit 152 (Figs. 1 and 12) to display an instruction visible by the user to pedal the bicycle to at least 25 mph. This instruction appears in the display window 212 of display unit 152 (Fig. 12). When the bicycle speed is above 25 mph, an audio signal sounds  
35 to indicate that the rider can stop peddling and remain seated on the saddle 22 (Fig. 1). The display window 212

also informs the rider to stop peddling after the audio signal sounds.

Block 214 (Fig. 11) starts the coast down calculation when the speed of the wheel 16 (Fig. 1) reaches a predetermined value, 23 mph in this case. Block 216 reads the speed of the wheel 16 (Fig. 1) while block 218 stores that speed in random access storage (RAM). Decision block 220 compares the speed from block 216 with a predetermined value, preferably 5 mph. If the speed is greater than 5 mph, the decision block returns the sequence to block 216 for re-reading the speed. The speed is checked at periodic intervals, preferably every 0.12 seconds. When the speed reaches 5 mph, the block 222 computes the deceleration of the bicycle  $dV/dT$ , where  $dV$  is the change in velocity, and  $dT$  is the change in time over which the velocity change occurred.

The deceleration is computed by a linear regression, with each consecutive 20 speed readings being averaged to get a series of velocities,  $v_1, v_2, v_3, \dots, v_n$  for each velocity  $v$  between 5 and 23 mph. A linear regression is then performed on the points:

$$x_i = (v_i + v_{i+1}) / 2$$

$$y_i = (v_i - v_{i+1}) / (20 * 0.12)$$

Where  $x_i$  = average system velocity (mph)

$y_i$  = system deceleration (mph/sec)

The linear regression gives an equation of the general form:

$$y = A (x) + B$$

which is the deceleration due to friction as a function of velocity. In the general form of the equation,  $A$  and  $B$  are constants,  $x_i$  corresponds to " $x$ " and  $y_i$  corresponds to " $y$ " which is the acceleration (or deceleration). The angular deceleration can be calculated by multiplying " $y$ " by 14.08 (rad/sec)/mph to get the angular deceleration due to friction as a function of velocity (mph).

Block 224 calculates the frictional resistance in the

system in terms of a frictional torque, from the equation:

$$T = Ia$$

Where  $T$  = Frictional Torque of alternator ( $N \cdot m$ )

$I$  = Mass moment of inertia ( $N \cdot m \cdot \text{sec}^2$ )

5  $a$  = angular acceleration ( $\text{rad}/\text{sec}^2$ )

The acceleration, or rather deceleration " $a$ " is the value computed by block 222 as a function of velocity. The system inertia is known or can be calculated, and should include the bicycle wheel 14 and tire 16 (Fig. 1). A  
10 typical value of the inertia, using a 900 gram wheel, is  $0.06296 \text{ N} \cdot \text{m} \cdot \text{sec}^2$ . The result calculated by block 224 is the frictional torque of the system under a no load condition. The constants A and B from block 224 are stored in RAM as shown in block 226.

15 The power to overcome the frictional torque as calculated above can be computed from the equation:

$$P = T * w$$

where:  $P$  = Power (watts)

$T$  = Torque ( $N \cdot m$ )

20  $w$  = angular velocity ( $\text{rad}/\text{sec}$ )

Block 227 uses this equation and the above data, with the appropriate conversion factors, to derive the power lost to friction in terms of the linear regression variables A and B:

25  $P_f = 11.829 * v * [A * v + B]$

where:  $P_f$  = power lost to friction (watts)

$v$  = bicycle velocity (mph)

$A$  = linear regression constant

$B$  = linear regression constant

30 The power lost to friction,  $P_f$ , represents the power lost in the system, including frictional power losses from the alternator 112 (Fig. 2). The stator of the alternator 112 (Fig. 2) may have a residual voltage applied, which although small, can cause frictional drag. By knowing the  
35 frictional losses of the system, the alternator 112 (Fig. 2) can apply power to the system to simulate road

conditions, and to compensate for the frictional losses of the system to increase the realism of the simulation.

The accuracy with which real loads are simulated also depends on how efficient the alternator 112 is in  
5 simulating the known loads. If the alternator 112 varies from the standard alternator used in deriving the original equations, applied loads will be less than accurate. To calibrate the alternator 112, the sequence then progresses to test 2, as shown in block 228.

10 Referring to the flow chart of Fig. 13, the power calibration of the alternator is performed by a second test, which determines the efficiency of the alternator 112 (Fig. 2) with respect to a standard alternator for which the performance characteristics are known, as for example,  
15 by measurement on a dynamometer. This standard alternator is used to derive the calibration equation for  $P_A$  described hereinafter, with  $m = 1$  in that equation. The comparison with the standard alternator allows compensation for variations in the electrical performance of the alternator  
20 113.

The rider is again instructed to pedal the bike to a predetermined speed (preferably 25 mph) by block 230, which causes a visual message to appear on the display 152 (Fig. 1). An audio signal informs the rider when the  
25 predetermined speed is reached. At that point the rider remains seated on the saddle 22 (Fig. 1) while the wheel 14 (Fig. 1) begins to coast to a rest. Block 232 begins the coast down test. Block 234 sets the DAC at a predetermined value, preferably 105. The voltage causes the alternator  
30 112 (Fig. 2) to apply a load to the roller 108 (Fig. 2). A mid range load is preferably used, and the 105 DAC value corresponds to a mid range load of about 20 mph.

Block 236 checks the speed beginning at a predetermined value, preferably 23 mph. Block 238 stores  
35 the speed in RAM, along with the voltage at the power resistor 243 in the alternator 112 (Fig. 2). This voltage

corresponds to the power out of the alternator 113 (Fig. 2). Decision block 240 checks to see if the speed is below a predetermined value, preferably 15 mph, and if not, it returns to block 236. The loop of blocks 236, 238 and 240 is repeated at periodic intervals, preferably every .12 seconds, until the 15 mph value is reached. At that point, several calculations can be made by the computer 200 (Fig. 1).

Block 242 calculates the power dissipated by the alternator 112 (Fig. 2) at a predetermined speed, 20 mph in this case. A regression analysis is performed to determine this value in order to eliminate the possibility of obtaining incorrect information by taking a single power reading at 20 mph. The voltage readings stored in RAM by block 238 are squared, and then a linear regression analysis is performed on the voltage squared as a function of velocity:

$$x_i = v_i$$

$$y_i = (E_i)^2$$

where:  $x_i$  = average system velocity (mph)  
 $v_i$  = incremental velocity readings (mph)  
 $y_i$  = system deceleration (mph/sec)  
 $E_i$  = voltage across power resistor 243 (volts)

The regression analysis results in a linear equation having the general form:

$$y = C(x) + D$$

where:  $y$  = a variable that corresponds to  $E_2$ , the voltage across the power resistor 243, squared (volts)

$C$  = a constant

$D$  = a constant

$(x)$  = a variable corresponding to velocity  $v$  (mph)

Thus the immediately preceding equation can be rewritten in the form:

$$E^2 = C * v + D$$

Where:  $E$  = voltage across power resistor 243 (volts)  
 $v$  = velocity (mph)  
 $C$  = a constant  
 $D$  = a constant

5 A one ohm external power resistor 243 (Fig. 2) is connected to the alternator 112 (Fig. 2), and the power dissipated by the external resistor 243 is  $E^2$ . The power across the external resistor 243 essentially measures the power out of the alternator 113 (Fig. 2). By substituting  
 10 the velocity of 20 mph the power dissipated at 20 mph can be found.

Block 244 computes the power into the alternator 112 (Fig. 2) as a function of velocity, by performing a linear regression analysis similar to that previously described.  
 15 This time, however, every 5 speed readings are averaged together to get  $v_1, v_2, \dots, v_n$  where the velocity  $v$  is between 15 and 23 mph. The regression is performed on the points:

$$x_i = (v_i + v_{i+1}) / 2$$

$$20 \quad y_i = [(v_i - v_{n+1}) / (5 * 0.12)] * [(v_i + v_{i+1}) / 2]$$

where:  $x_i$  = system velocity (mph)  
 $y_i$  = deceleration times velocity (mph)<sup>2</sup>/sec

The result of this regression is a linear equation, which when multiplied by the proper factors, gives the  
 25 power into the alternator as a function of velocity:

$$P_i = [F * v + G] * 11.829$$

where:  $P_i$  = power into alternator (watts)  
 $v$  = velocity (mph)  
 $F$  = regression constant  
 30  $G$  = regression constant

Block 246 determines the electrical efficiency of the alternator 112 (Fig. 2) by taking the ratio of the power out, over the power input, at 20 mph.

$$n_u = [(E^2) / (P_{in} - P_f)]_{20 \text{ mph}}$$

35 where:  $n_u$  = user's alternator efficiency  
 $E^2$  = alternator output (watts)

$P_{in}$  = alternator input power (watts)

$P_f$  = power lost to friction (watts)

Block 248 determines the calibration factor which gages the performance of a particular user's alternator with the performance of the standard alternator used to derive the foregoing equations. The calibration factor is:

$$m = n_u / n_{cal}$$

where:  $m$  = multiplying factor for alternator

$n_u$  = user electrical efficiency

10  $n_{cal}$  = calibrated alternator efficiency

The calibration factor  $m$  is stored in RAM by block 250.

The power a rider puts into the alternator is calculated by knowing the power out of the alternator 112, and the alternator efficiency, as compared to a standard. The voltage is read across the power resistor 243 in the alternator 112 (Fig. 2). The voltage is used to calculate the power exerted by the rider. The power is then multiplied by the calibration factor,  $m$ , to compensate for any variations between the user's apparatus, and the standard apparatus.

The display window 212 (Fig. 12) is used to display the power values and associated information for use by the rider. Following the completion of the coast down tests of Figs. 11 and 13, the information displayed includes the linear regression constants  $A$  and  $B$  from block 224 (Fig. 11), the calibration factor  $m$  from block 248 (Fig. 13). The correlation coefficients for such equations as those of blocks 242 and 244 of Fig. 13 can also be displayed.

30 A computer source code listing for the calibration steps as described generally in Figs. 11 and 13 is attached as Appendix A.

The calibration of Figs. 11 and 13 serves to identify the various factors that can cause the load to vary from what is theoretically predicted. By knowing these variable factors, and calibrating the apparatus to account for these

variables or to compensate for frictional losses, the accuracy of the load that is applied is greatly increased, thus giving an increasingly realistic ride simulation. The increased accuracy of the load simulation works in combination with the increased realism provided by the apparatus on which the bike is mounted as described with respect to Figs. 1-10, in order to provide for a realistic training and exercise apparatus, both as to load exerted, and operational "feel."

Once the apparatus is calibrated, the correct loads must be determined to properly simulate the desired riding conditions. The torque which the alternator 112 presents to the exercise apparatus for the rider to overcome was found to vary linearly with the voltage across the power resistor 243 squared ( $E^2$ ) for one particular speed with the y-intercept equal to zero, where the voltage squared was plotted on the horizontal (x) axis, and the power was plotted on the vertical (y) axis. The slope of these speed or velocity lines was found to be a function of the exponent of the inverse of the speed, as:

$$\text{slope} = 0.12832 * e^{(1/v)} - 0.12903$$

where:  $v$  = rider velocity (mph)

Using this information, the equation for  $y_i$  from block 222, the equation for  $n_u$  from block 246, and appropriate conversion factors, the power dissipated by the alternator 112 can be written as:

$$P_A = m[14.08 * v * E^2 * (0.1283 e^{(1/v)} - 0.12903)]$$

where:  $P_A$  = alternator power (watts)

$E$  = power resistor voltage (volts)

$v$  = road speed (mph)

$m$  = calibration factor

The computer 200 can accurately simulate the desired environmental loads experienced by a bicycle rider. The appropriate loads are determined as follows, in the preferred embodiment.

The inertia of the bicycle and rider is simulated by

the flywheel 116 (Fig. 2), as previously described. The alternator 112 also has some inertia which must be considered. The inertia of a 22 pound flywheel ( $0.05648 \text{ N} \cdot \text{m} \cdot \text{sec}^2$ ) when combined with the inertia of the alternator 112 (Fig. 2) has the same inertia as a 113 pound man with a 25 pound bike.

The rolling resistance of the bike is given by the equation:

$$F_R = 4.448 * C_R * W$$

Where:  $F_R$  = rolling friction (N)  
 $C_R$  = coefficient of friction  
 $W$  = weight of rider and bicycle (lbs)

This equation assumes the bearing friction is accounted for in the coast down tests of Figs. 11 and 13. A coefficient of friction of .004 is preferably used as a median representation of the friction for good clincher tires on a variety of surfaces.

The aerodynamic drag of a bicycle rider is given by the equation:

$$F_D = 0.54 * A * v^2$$

Where:  $F_D$  = air drag (N)  
 $A$  = frontal area of bicycle and rider ( $\text{m}^2$ )  
 $v$  = velocity of bicycle (m/sec)

This drag equation assumes a drag coefficient of 0.9, and the standard air density at sea level. The frontal area  $A$  changes with rider position and rider size. Assuming that the frontal area varies linearly with rider weight, and a 125 pound rider has a frontal area of  $0.306 \text{ m}^2$  while a 180 pound rider has a frontal areas of  $0.409 \text{ m}^2$ , and a 25 pound bike with the bike's frontal area included in the preceding figures, then the aerodynamic drag equation becomes:

$$F_D = v^2 [(0.00103 * W) + 0.0113]$$

Where:  $F_D$  = air drag (N)  
 $v$  = velocity of bicycle (m/sec)  
 $W$  = weight of rider and bicycle (lbs)

If the velocity is given in units of mph, then the first and second constants become 0.000206 and 0.00227 respectively. Further variations in the aerodynamic drag equation can be made if it is desired to simulate race conditions such as the position of a rider within a pack of riders. A 30% reduction in air drag is believed to be appropriate for use in the illustrated embodiment if a rider were within a pack of riders.

Assuming a 25 pound bicycle, the load on a bike rider due to inclined or graded surfaces, such as hills, can be calculated as:

$$F_G = 4.448 * G * W$$

Where:  $F_G$  = force due to grade (N)

$G$  = percent grade (e.g. 45% angle = 100% grade)

$W$  = weight of rider and bicycle (lbs)

Since power is equal to force times velocity, the power experienced by a bike rider can be obtained by combining the equations for the above forces, to yield the equation:

$$P_R = 0.447 * v * (F_R + F_D + F_G)$$

Where:  $P_R$  = road power for rider (watts)

$v$  = velocity (mph)

$F_R$  = force from rolling resistance (N)

$F_D$  = force from air drag (N)

$F_G$  = force from hills (N)

For given riding conditions from the above equation, the speed for the rider can be calculated, and an appropriate voltage determined to be applied to the alternator 112 in order to simulate that road power. A feedback loop is used in the monitoring and adjustment of the load exerted by the alternator 112. The power a rider is exerting is calculated from the equation:

$$P_{in} = P_A + P_f$$

Where:  $P_{in}$  = rider power exerted by rider (watts)

$P_A$  = alternator power into system (watts)

$P_f$  = friction power (watts)

The computer 200 (Fig. 1) controls and modifies the DAC value, which in turn varies the alternator power  $P_A$  as needed to simulate the riding conditions. The DAC value is modified according to the equation:

$$5 \quad \text{DAC}_N = \text{DAC}_O (P_{in} / P_R)$$

Where:  $\text{DAC}_N$  = new DAC value

$\text{DAC}_O$  = previous DAC value

$P_{in}$  = rider power in (watts)

$P_R$  = desired rider power in (watts)

10 Preferably the  $\text{DAC}_N$  value is limited to a maximum increase of 40 percent. By using the above load equations and calibration modes, the load experienced by the rider can be varied in a more realistic manner than previously possible.

15 The computer 200 can be programed to simulate several riding conditions. Referring to Fig. 12, a programming capability is provided whereby the rider can use the keys on the keyboard 252 to select desired loading conditions for specified times and/or speeds. Similarly, the keyboard  
20 252 can be used to recall a stored loading program from the computer 200. One such program is the race mode where the rider competes against other racers simulated by the computer 200.

Fig. 14 shows an exemplary display window 212 for the  
25 race mode. A first cursor 254 on the display window 212 indicates the position of the rider in a window 256 which displays the pack position so the rider can visualize his/her position with respect to other racers. The window 212 also displays the rider's speed, the elapsed time, the  
30 miles traveled, the cadence or pedal rpm, and the rider's heart rate. An elevation profile 258 of the course and the rider's position on the course is also displayed in the window 212. A second cursor 257 indicates the rider's position on the course so the rider can visualize the  
35 rider's position with respect to not only the pack via window 256, but also with respect to the overall course and

race. The blocks in the window 212 labeled "OTB" and "OTF" allow the first cursor 254 to move within and out of the pack a predetermined extent. "OTB" means "off the back" of the pack, and "OTF" means "off the front" of the pack.

5       The race mode can use preprogrammed race courses, as for example the course used in the 1984 Olympics. Another preprogrammed course would be a constant incline, sometimes referred to as a fixed grade, where the amount of the incline or grade can be selected by the rider.  
10       Alternately, the rider can independently program a course created by the rider. In either event, the computer 200 will control the alternator 112 (Fig. 2) to provide the appropriate loads that simulate the terrain traversed over the length of the course. The rider can select the  
15       difficulty of the competition by use of the keyboard 252, in order to compete against riders of varying competence. The greater the competence of the riders, the faster the course would be traversed.

      In real races, the riders will bunch up to form a  
20       "pack" for much of the race. The pack of riders will progress at varying speeds, sometimes maintaining constant speed, while sometimes increasing speed as riders vie for position. The computer 200 is thus programed to vary the pack speed, preferably in a random manner so the rider can  
25       decide whether to alter position as the pack speed varies.

      As previously mentioned, the load experienced by a rider can vary depending on the rider's position with respect to the pack since the wind resistance is less for  
30       riders in the pack than for those riders who lead or trail the pack. There is thus provided a rider controllable position relative to a pack of simulated riders of a preselected capability, with the rider position relative to the pack varying the wind load experienced by the rider.

35       Fig. 15 shows a flow chart of a race mode simulation, while Appendix B contains a computer source code for this

simulation and related pack position and power calculations. Block 260 allows the rider to select the level of competition for the race. The more difficult the competition, the greater the loads which must be exerted by the rider on the apparatus in order to keep up with the competition. The loads exerted on the rider by the exercise apparatus, however, are determined by the selected race course as simulated by the alternator 112 (Fig. 2).

The selection of the race course or of the level of competition from the simulated riders is made by using the keyboard 252. Block 262 allows the rider to select the racecourse. A fixed grade may be input, a preprogrammed course can be selected, or a new course can be input by the rider, again by using the keyboard 252 in conjunction with computer algorithms. Block 264 allows the rider's weight to be entered since that affects the load simulation.

Block 266 reads the A/D converter which in turn reads the analog voltage across the external power resistor 243 connected to the alternator 112 (Fig. 2). Block 268 converts that analog voltage to a digital value where the digital value is linear with a maximum of 255. The 255 digital value corresponds to a voltage of 25 volts. Block 270 then computes the appropriate power for the given road simulation according to the formula:

$$P_{total} = P_f + P_A$$

Where:  $P_{total}$  = total power to be overcome by rider (watts)

$P_f$  = power lost to friction (watts)

$P_A$  = alternator power (watts)

The equations for  $P_f$  and  $P_A$  have been previously defined.

Block 272 averages the total power  $P_{total}$  over a one second period and displays that power on the display unit 152 (Fig. 1). Block 274 computes the pack power based on the level of experience selected by the rider. Block 276 computes the pack distance to determine the position on the

racecourse. Block 278 displays the position of the rider with respect to the pack position, via window 256 (Fig. 14). Block 280 checks the speed of the rider so that block 282 can compute the wind force on the rider, using the previously discussed formula for air drag  $F_D$ .

Decision block 286 checks to determine if the rider is within the pack, and if so, block 286 reduces the air drag to account for the reduced wind resistance from being in the pack. The reduction is 30 % in the described embodiment. Block 288 computes the loads from the grade and rolling resistance,  $F_G$  and  $F_R$ , as previously discussed. Block 290 computes the desired power,  $P_r$ , as previously described, to be applied to the alternator 112 (Fig. 2) to simulate the above combination of loads.

Once the desired amount of power needed to simulate the riding conditions is determined, decision block 292 checks to see if the desired power is equal to the actual power resistance being exerted on the apparatus by the alternator 112 (Fig. 2) and inherent friction in the system. If the desired power is the same power being applied, no adjustment is necessary and the computer algorithm of Fig. 15 returns to block 266.

If the desired power is not equal to the power being applied, then the program proceeds on to block 294 which computes the percentage ratio of the desired power and applied power. Decision block 296 determines whether this percentage difference is within predetermined limits of acceptability. A 40% difference in the percentage ratio acceptable in the described embodiment. If the percentage difference is beyond the predetermined value, the program proceeds to block 298 where the percentage ratio is adjusted. To prevent sudden surges in load variability, any adjustment of the percentage ratio is limited so as not to exceed a predetermined range, which is plus or minus 40%. in the illustrated embodiment. A no decision from block 296 leads to block 300, as does the natural exit from

block 298. Block 300 calculates a new DAC value according to the equation:

$$DAC_{new} = (\%)(DAC_{old})$$

Where:  $DAC_{new}$  = new DAC value (volts)

5  $DAC_{old}$  = prior DAC value (volts)

% = percentage ratio from block 294 or 298.

Following the adjustment of the DAC value, the program returns to block 266 for another iteration. These iterations are repeated at least every second. This  
10 computer algorithm allows the rider to train, practice, and experience the exertion required to participate in well recognized courses, in a realistic simulation, and monitor the rider's performance on an absolute time basis, and on a relative basis with respect to a pack of riders having a  
15 predetermined ability.

Another capability of the apparatus is to monitor the rider's heart rate, and adjust the load experienced by the rider to maintain the heart rate within predetermined limits. A flow chart of a computer program to achieve this  
20 purpose is shown in Fig. 16. A copy of a computer source code implementing this flow chart is attached as Appendix C.

The rider initiates the program by keying in the request from keyboard 252 (Fig. 12). Block 300 initiates  
25 the program and 226-Arts requests the rider to input information on the upper and lower limits for the heart rate. If no values are input, a default program (not shown) displays a request on window 212 that the rider input the age and sex of the rider, which information is  
30 input by keyboard 252. For males, the maximum heart rate is calculated as 220 minus the age. For females, the maximum heart rate is calculated as 226 minus the age. Using this information, limits of 70 to 85% the maximum attainable heart rate during an all out effort are selected  
35 from data accessible to computer 200 (Fig. 1).

Block 301 sets the DAC to zero so there is no load

exerted by the alternator 112 (Fig. 2), and tells the rider to warm up by a display message in display window 212. As indicated in block 302, the warm up lasts for a predetermined time, two minutes in this case.

5        Preferably, the rider makes the necessary connections before the warmup period begins so that information on the rider's heart rate can be input into the computer 200 in the display unit 152 (Fig. 1). Various methods known in the art can be used to monitor the rider's heart rate and  
10       transmit it to the computer. Preferably, however, the rider wears a chest belt containing a pulse sensor to sense the rider's heart rate. The belt also preferably contains a transmitter so the information can be transmitted to a receiver in the computer 200 in the display unit 152 (Fig.  
15       1). Such devices are known in the art and are not described in detail herein.

         The upper limit (UL) and lower limit (LL) are used in the decision block 306 to determine whether the heart rate (HR) is such that the load exerted on the  
20       apparatus by the alternator 112 (Fig. 2) should be increased, decreased, or remain the same. Decision block 306 monitors the heart rate, and if it is within a predetermined range then the load is not altered as indicated in block 310, and the display window displays a  
25       signal to indicate all is well, as in block 312, after which the program returns to recheck the heart rate. The predetermined range selected in Fig. 16 is that the heart rate must be greater than:

$$LL + (UL - LL) * .2$$

30       and less than:

$$UL - (UL - LL) * .2$$

Where:    LL = lower limit (from block 306)

         UL = upper limit (from block 306)

         Essentially, no consideration is given to changing the  
35       load until the heart rate approaches to within 20% of either the upper or lower limits.

If the heart rate was within 20% of the lower heart rate limit, then the algorithm proceeds to decision block 320 which checks to see if the DAC value just recently increased. Since the DAC value affects the load exerted by the alternator 112 (Fig. 2), this step essentially checks to see if the load exerted on the rider has recently increased. If the answer is no, the algorithm proceeds to block 324. If the answer is yes, the algorithm proceeds to block 322 which checks to determine whether the DAC value has been unchanged for more than a predetermined time, 40 seconds in this case. This step is essentially checking to see if the load exerted on the rider has been unchanged for 40 seconds. If the DAC value has not changed for at least 40 seconds, the program returns to block 306 and re-reads the heart rate. If the DAC value has not changed for 40 seconds or more, the program proceeds to decision block 324, which checks to see if the DAC value is at a predetermined level, which in this case is selected as 255. As previously mentioned, 255 is the maximum DAC value, and corresponds to a voltage of 12 volts at the field coil of alternator 112 (Fig. 2). If the DAC value is 255, the program goes to block 326 which displays a request for the rider to increase the effort being exerted, after which it returns to block 306. If the DAC value is below 255, then the program proceeds to block 328 which increases the power by a predetermined amount, which was selected as 10 watts in the preferred embodiment. The program then returns to decision block 306.

If the rider's heart rate is within 20 % of the upper heart rate limit, then the program goes to decision block 330 which checks to see if the heart rate has exceeded the upper limit by a predetermined amount, which was selected to be 5 in Fig. 16. If the answer is yes, the heart rate is too high and the program goes to block 332 which sets the DAC to zero to reduce the load, displays a signal on the display unit 152 (Fig. 1) telling the rider to decrease

effort, and gives an audio signal (a beep) until the heart rate is lowered to within the pre-specified limits. The program then returns to block 306 to check the heart rate.

5 If the decision from block 330 is that the rider's heart rate is not greater than the predetermined amount, then the program goes to decision block 334, which checks to see if the DAC was just decreased. If it has just decreased, then the program proceeds to decision block 336 to see how long the heart rate has been heart rate has been  
10 above the upper limit. If the DAC has not just decreased, then the algorithm proceeds to block 338.

Block 336 checks to see whether the DAC has changed within the last 20 seconds, and if so the program returns to block 306. If the DAC has been unchanged for 20 seconds  
15 or more, then the program proceeds to decision block 338.

Block 338 checks the DAC value, and if it is zero, the program proceeds to block 332 which was previously described. If the DAC value is not zero, then block 340 decreases the power to the alternator 112 (Fig. 2) by a  
20 predetermined amount, which is 10 watts in Fig. 16. After decreasing the power, the program returns to block 306.

The algorithm of Fig. 16 thus maintains the load on the exercise apparatus so that the heart rate stays within predetermined limits, and initiates corrective measures as  
25 the heart rate approaches those limits. The fast and accurate response of the alternator 112 (Fig. 2) to the load variations allows the loads to be adjusted quickly and accurately enough to maintain the heart rate within the preselected limits. The display unit 152 (Fig. 1) provides  
30 visual and audio communication to the rider to further maintain the effectiveness of the system.

When combined with the prior improvements, the method and apparatus for controlling the heart rate allows a racer to optimize the training for a race. The apparatus for  
35 supporting the racer's bicycle provides a realistic ride simulation or "feel." The calibration of the friction and

alternator efficiency allow the loads to be accurately simulated and to accurately simulate various race conditions. The effects of wind load and pack position can be simulated. The computer and race course selection  
5 allows a variety of races to be simulated, so the rider can practice any pre-programmed course, or program independently. The ability to select various levels of competition, and to race against the simulated competition provides race incentive. The random variation of pack  
10 performance during a race allows the racer to practice various race strategies. The heart rate monitor allows the racer to track physical performance while having the exercise device take steps to control the load which affects the heart rate.

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Huntsville Macro Assembler c5002 cross assembler for PC-DOS 2.0 v1.03L Page  
Module: EIK14

```

;COPYRIGHT 1986 FRONTLINE TECHNOLOGY, INC.
F743*      CALIBRATE
F743*4C3D81 JMP MM0 ;^FOR NOW
F746*9C0C02 STZ DACTMF ;ZERO THESE
F749*9C0402 STZ STARTFLG
F74C*9C2102 STZ SIGNFLG
F74F*4F00    LDA #0
F751*8D407F STA $7FA0 ;0 DAC
F754*2058D6 JSR RESVAL ;RESET ALL VALUES

F757*      CALIBRATE0
F757*200FF9 JSR CALIB0SF ;"CALIBRATE" AND "SPEED"
F75A*4F22    LDA #$22
F75C*8501    STA ADDR+1
F75E*6400    STZ ADDR
F760*A96E    LDA #LOW M286 ;"PRESS THE "START" MENU KEY TO BEGIN CALIBRATION"
F762*A053    LDY #HIGH M286
F764*2058A3 JSR PRMSG
F767*A924    LDA #$24
F769*8501    STA ADDR+1
F76B*A99F    LDA #LOW M287 ;"PRESS THE "HELP"..."
F76D*A053    LDY #HIGH M287
F76F*2058A3 JSR PRMSG

F772*A998    LDA #LOW M195 ;"START"
F774*A04E    LDY #HIGH M195
F776*20E7DA JSR INMSGC1 ;1ST SOFTKEY
F779*A96E    LDA #LOW M65 ;"PREVIOUS MENU"
F77B*A041    LDY #HIGH M65
F77D*20F4DA JSR INMSGC2 ;2ND SOFTKEY
F780*A9FC    LDA #LOW M81 ;"MAIN MENU"
F782*A042    LDY #HIGH M81
F784*2001DB JSR INMSGC3 ;3RD SOFTKEY

F787*      CALIBRATE2
F787*645F    STZ KEY

F789*      CALIBRATE3
F789*A55F    LDA KEY ;ANYTHING FROM KEYBOARD?
F78B*F0FC    BEQ CALIBRATE3 ;NO
F78D*C911    CMP #$11 ;START
F78F*F015    BEQ CALIBRATE5
F791*C912    CMP #$12 ;PREVIOUS MENU
F793*D003    BNE ++5
F795*4CC7C0    JMP SETUP
F798*C913    CMP #$13 ;MAIN MENU
F79A*D003    BNE ++5
F79C*4C3D81    JMP MM0
F79F*C93F    CMP #'?' ;HELP
F7A1*D0E4    BNE CALIBRATE2

;HELP MENU HERE

```

```

F7A3*2068BE      JSR BEEP

F7A6*           CALIBRATE5 ;START
F7A6*8DB07F      STA $7FB0 ;START A/D
F7A9*AD0A02      LDA STARTFLG ;SAVE
F7AC*48          PHA
F7AD*2068D6      JSR RESVAL ;RESET ALL VALUES
F7B0*68          PLA
F7B1*8D0A02      STA STARTFLG ;RESTORE
F7B4*2068BE      JSR BEEP
F7B7*200FF9      JSR CALIBDSP ;"CALIBRATE" AND "SPEED"
F7BA*A922        LDA #$22
F7BC*8501        STA ADDR+1
F7BE*6400        STZ ADDR
F7C0*A9CA        LDA #LOW M288 ;"PEDAL YOUR BICYCLE..."
F7C2*A053        LDY #HIGH M288
F7C4*2058A3      JSR PRTMSG
F7C7*A980        LDA #$80
F7C9*8500        STA ADDR
F7CB*A900        LDA #LOW M289 ;"YOU HEAR THE BEEP."
F7CD*A054        LDY #HIGH M289
F7CF*2058A3      JSR PRTMSG

F7D2*A939        LDA #LOW M291 ;"CANCEL"
F7D4*A054        LDY #HIGH M291
F7D6*20E7DA      JSR INUMSG01 ;1ST SOFTKEY
F7D9*209FAS      JSR IRQENABLE ;ENABLE IRQ'S
F7DC*A9C3        LDA #LOW DACDAT ;BEGINNING RAM FOR SPEED
F7DE*851C        STA PNT14
F7E0*A905        LDA #HIGH DACDAT
F7E2*851D        STA PNT14+1
F7E4*A9A0        LDA #LOW CRSDAT ;BEGINNING RAM FOR VOLTAGE
F7E6*851A        STA PNT13
F7E8*A90E        LDA #HIGH CRSDAT
F7EA*851B        STA PNT13+1
F7EC*9C0B02      STZ EXPFLG ;CLR FLG

F7EF*           CALIBRATE6
F7EF*645F        STZ KEY
F7F1*9C2102      STZ SIGNFLG

F7F4*           CALIBRATE7
F7F4*A55F        LDA KEY ;ANYTHING FROM KEYBOARD?
F7F6*D007        BNE CALIBRATE8 ;YES
F7F8*A5A4        LDA TIMER3 ;0.12 SEC?
F7FA*D00A        BNE CALIBRATE9 ;NO
F7FC*4CBCF8      JMP CALIBRATE11

F7FF*           CALIBRATE8
F7FF*C911        CMP #$11 ;CANCEL
F801*D0EC        BNE CALIBRATE6
F803*4C43F7      JMP CALIBRATE

F806*           CALIBRATE9 ;0.12 SEC

```

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Huntsville Macro Assembler 65002 cross assembler for FI-DCS 2.0 01.62L Page 3  
Module: BIF1

```

F806*202B5D    JSR ADAUG ;RUNNING 10 A/D READINGS
F80F*4544      LDA RPMFLG ;A SPEED PULSE YET?
F80E*F0E7      BEQ CALIBRATE7 ;NO
F80D*2062E7    JSR RPMCALC ;CALCULATE SPEED
F810*200B02    BIT EXPFLG
F813*7065      BVS CALIBRATE10A ;ALREADY FAST 23 MPH ON COAST DOWN
F815*3043      BMI CALIBRATE10 ;FAST 25 MPH ON UP SIDE
F817*AD2903    LDA SPDHEX ;>25.5 MPH?
F81A*D007      BNE CALIBRATE9A ;YES
F81C*AD2403    LDA SPDHEX+1 ;25 MPH YET?
F81F*C9FA      CMP #250
F821*90CC      BCC CALIBRATE6 ;NO

```

```

F823*        CALIBRATE9A
F823*AD2102    LDA SIGNFLG ;2 TIMES? (MINIMIZE NOISE)
F826*0005      BNE CALIBRATE9A1 ;YES
F828*EE2102    INC SIGNFLG
F82B*80C7      BRA CALIBRATE7

```

```

F82D*        CALIBRATE9A1
F82D*2048BE    JSR BEEP
F830*A980      LDA #80
F832*8D0B02    STA EXPFLG
F835*200FF9    JSR CALIBDSP ;"CALIBRATE" AND "SPEED"
F838*A922      LDA #22
F83A*8501      STA ADDR+1
F83C*6400      STZ ADDR
F83E*A918      LDA #LOW M290 ;"CONTINUE COASTING..."
F840*A054      LDY #HIGH M290
F842*2058A3    JSR PRMSG
F845*A939      LDA #LOW M291 ;"CANCEL"
F847*A054      LDY #HIGH M291
F849*20E7DA    JSR INVMSGC1 ;1ST SOFTKEY
F84C*2C0A02    BIT STARTFLG ;DAC 105? (2ND COASTDOWN)
F84F*109E      BPL CALIBRATE6 ;NO
F851*A969      LDA #105 ;LOAD DAC WITH 105
F853*8DA07F    STA $7FA0
F856*4CEFF7    JMP CALIBRATE6

```

```

F859*        CALIBRATE10
F859*AD2903    LDA SPDHEX ;>255?
F85C*D091      BNE CALIBRATE6 ;YES
F85E*AD2A03    LDA SPDHEX+1
F861*C9E7      CMP #231 ;CROSSED 230 YET?
F863*9003      BCC **5
F865*4CEFF7    JMP CALIBRATE6 ;NO
F868*AD2102    LDA SIGNFLG ;2 TIMES?
F86B*D005      BNE CALIBRATE10AA ;YES
F86D*EE2102    INC SIGNFLG
F870*8082      BRA CALIBRATE7

```

```

F872*        CALIBRATE10AA
F872*A9FF      LDA #FF
F874*8D0B02    STA EXPFLG
F877*4CEFF7    JMP CALIBRATE6

```

SUBSTITUTE SHEET

F87A*	CALIBRATE10A
F87A*200A02	BIT STARTFLG ;0 OF 105?
F87D*1010	BPL CALIBRATE10B ;0
F87F*AD2A03	LDA SPDHEX+1
F882*1957	CMP #151 ;15 MPH YET?
F884*900E	BCC **5
F886*40EFF7	JMP CALIBRATE6
F88F*AD2102	LDA SIGNFLG ;2 TIMES?
F890*D006	BNE CALIBRATE10A1 ;YES
F89E*EE2102	INC SIGNFLG
F891*4CF4F7	JMP CALIBRATE7
F894*	CALIBRATE10A1
F894*A900	LDA #0
F896*8D407F	STA \$7FA0 ;RE-ZERO DAC
F899*4C47FA	JMP CALDAC105 ;^FOR NOW
F89C*	CALIBRATE10B
F89C*AD2A03	LDA SPDHEX+1
F89F*C933	CMP #51 ;CROSSED 5 MPH YET?
F8A1*9003	BCC **5
F8A3*40EFF7	JMP CALIBRATE6 ;NO
F8A6*AD2102	LDA SIGNFLG ;2 TIMES?
F8A9*D006	BNE CALIBRATE10B1 ;YES
F8AB*EE2102	INC SIGNFLG
F8AE*4CF4F7	JMP CALIBRATE7
F8B1*	CALIBRATE10B1
F8E1*2058F9	JSR CALDAC0 ;DO CALCULATION FOR 0
F8B4*A9FF	LDA #\$FF
F8E6*8D0A02	STA STARTFLG
F8B9*4CA6F7	JMP CALIBRATES
F8BC*	CALIBRATE11 ;DISPLAY SPEED
F8BC*A903	LDA #3
F8BE*85A4	STA TIMER3
F8C0*202DF9	JSR SPEEDISP
F8C3*2C0B02	BIT EXFFLG ;CALIBRATION RUNNING?
F8C6*5044	BVC CALIBRATE12 ;NO
F8C8*A000	LDY #0
F8CA*AD2A03	LDA SPDHEX+1 ;STORE SPEED
F8CD*911C	STA (PNT14),Y
F8CF*E61C	INC PNT14
F8D1*D002	BNE **4
F8D3*E61D	INC PNT14+1
F8D5*A51D	LDA PNT14+1
F8D7*C940	CMP #340 ;OUT OF RAM?
F8D9*D006	BNE CALIBRATE11A ;NO
	;OVER RAM LIMIT - DISPLAY SOMETHING
F8DB*2068BE	JSR BEEP
F8DE*4CDEF8	JMP *
F8E1*	CALIBRATE11A

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 v1.02L Page: 3  
Module: ECHM

```

F8E1*200A02    BIT STARTFLG
F8E4*1026      BPL CALIBRATE12 ;DACC

F8E6*         CALIBRATE11E
F8E6*AD00      LDY #0
F8E6*AD4904    LDA ADTOT ;STORE A/D SUM OF 10 READINGS
F8EE*511A      STA (PNT13),Y
F8ED*08        INY
F8EE*AD4A04    LDA ADTOT+1
F8F1*911A      STA (PNT13),Y
F8F3*18        CLC
F8F4*A51A      LDA PNT13
F8F6*6902      ADC #2
F8F8*851A      STA PNT13
F8FA*A51E      LDA PNT13+1
F8FC*6920      ADC #0
F8FE*851B      STA PNT13+1
F900*A51E      LDA PNT13+1
F902*C940      CMP #$40 ;OUT OF RAM?
F904*D006      BNE CALIBRATE12 ;NO
               ;OVER RAM - DISPLAY SOMETHING
F906*2068BE    JSR BEEP
F909*4C09F9    JMP *

F90C*         CALIBRATE12
F90C*4CF4F7    JMP CALIBRATE7

F90F*         CALIBDSP ;DISPLAY "CALIBRATE" AND "SPEED"
F90F*206BA3    JSR CLRDSP
F912*20C3F5    JSR HVLIN ;HORIZ AND VERT LINES
F915*6400      STZ ADDR
F917*A920      LDA #$20
F919*8501      STA ADDR+1
F91B*A9A9      LDA #LOW M198 ;"CALIBRATION"
F91D*A04E      LDY #HIGH M198
F91F*2058A3    JSR PRTMSG
F922*A924      LDA #$24
F924*8501      STA ADDR+1
F926*A91E      LDA #LOW M213 ;"SPEED"
F928*A04F      LDY #HIGH M213
F92A*4C58A3    JMP PRTMSG

F92D*         SPEEDISP ;DISPLAY SPEED
F92D*AD2903    LDA SPDHEX
F930*856C      STA HEX+1
F932*AD2A03    LDA SPDHEX+1
F935*856D      STA HEX+2
F937*646B      STZ HEX
F939*201FBA    JSR HEXASC
F93C*A924      LDA #$24
F93E*8501      STA ADDR+1
F940*6400      STZ ADDR
F942*A56B      LDA ASCI+5

```

**SUBSTITUTE SHEET**

```

F944*A006      LDY #6
F946*9100      STA (ADDR),Y
F948*13        INY
F949*A509      LDA ASCI+6
F94E*9100      STA (ADDR),Y
F94D*09        INY
F94E*A92E      LDA #1
F950*9100      STA (ADDR),Y
F952*09        INY
F953*A50A      LDA ASCI+7
F955*9100      STA (ADDR),Y
F957*60        RTS

F95E*          CALDAC0:COAST DOWN (0 DAC) COMPLETE

F958*A9C3      LDA #LOW DACDAT ;BEGIN SPEED RAM
F95A*851E      STA PNT15
F95C*A905      LDA #HIGH DACDAT
F95E*851F      STA PNT15+1
F960*20C5FD    JSR RESCALVAL ;RESET CALIB VALUES

F963*          CALDAC0F
F963*6428      STZ MCAND
F965*6429      STZ MCAND+1
F967*A000      LDY #0
F969*A213      LDX #19

F96E*          CALDAC0G ;SUM OF 20 SPEEDS
F96E*18        CLC
F96C*B11E      LDA (PNT15),Y
F96E*6529      ADC MCAND+1
F970*8529      STA MCAND+1
F972*A900      LDA #0
F974*6528      ADC MCAND
F976*8528      STA MCAND
F978*CA        DEX
F979*3008      BMI CALDAC0H
F97B*2036FA    JSR INCPNT15 ;NEXT POINT
F97E*D0EB      BNE CALDAC0G ;NOT DONE YET
F980*4CEDF9    JMP CALDAC0K ;YES

F983*          CALDAC0H
F983*2033F4    JSR RDYFAC
F986*A529      LDA MCAND+1
F988*85DA      STA FACLO
F98A*A528      LDA MCAND
F98C*85D9      STA FACMO
F98E*207565    JSR NORMAL ;NORMALIZE TO FLOATING POINT
F991*A268      LDX #LOW FACTMP1 ;STORE
F993*A003      LDY #HIGH FACTMP1
F995*200D68    JSR MOVMF
F998*AD4903    LDA HRTCNT ;1ST TIME?
F99B*F03A      BEQ CALDAC0I ;YES
F99D*A96D      LDA #LOW FACTMP2 ;GET LAST AVG
F99F*A003      LDY #HIGH FACTMP2

```

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 v1.82L Page 7  
Module: EIR1-

```

F9A1*20ED64      JSR FSUB ;LAST - THIS AVG
F9A4*204568      JSR MOVAF
F9A7*A991        LDA #LOW INT480 ;480 20*.12*20(AVG)*10(SPEED)
F9A9*A064        LDY #HIGH INT480
F9AB*20DF67      JSR MOVFM
F9AE*20EAFD      JSR FPDIV
F9B1*A263        LDX #LOW FACTMP ;Y
F9B3*A003        LDY #HIGH FACTMP
F9B5*200D6E      JSR MOVMF

F9B8*A968        LDA #LOW FACTMP1 ;THIS READING
F9BA*A003        LDY #HIGH FACTMP1
F9BC*20DF67      JSR MOVFM
F9BF*A96D        LDA #LOW FACTMP2 ;LAST READ
F9C1*A003        LDY #HIGH FACTMP2
F9C3*200465      JSR FADD

F9C6*A9B4        LDA #LOW INT0025 ;0.0025 1/(2*20(AVG)*10(SPEED))
F9C8*A064        LDY #HIGH INT0025
F9CA*206566      JSR FMULT
F9CD*A27C        LDX #LOW ARGTMP ;X
F9CF*A003        LDY #HIGH ARGTMP
F9D1*200D68      JSR MOVMF

F9D4*2038FC      JSR LINREG

F9D7*            CALDAC0I
F9D7*A204        LDX #4 ;STORE THIS AS LAST READ

F9D9*            CALDAC0J
F9D9*BD6803      LDA FACTMP1,X
F9DC*9D6D03      STA FACTMP2,X
F9DF*CA          DEX
F9E0*10F7        BPL CALDAC0J
F9E2*EE4903      INC HRTCNT
F9E5*2036FA      JSR INCPNT15 ;NEXT POINT
F9E8*F003        BEQ CALDAC0K ;DONE
F9EA*4C63F9      JMP CALDAC0F ;NEXT AVG

F9ED*            CALDAC0K
F9ED*2033F4      JSR RDYFAC
F9F0*CE4903      DEC HRTCNT
F9F3*AD4903      LDA HRTCNT ;NEED TO DECREMENT?
F9F6*85DA        STA FACLO
F9F8*20B6FC      JSR ACALC
F9FB*A99B        LDA #LOW INT11829 ;11.829
F9FD*A064        LDY #HIGH INT11829
F9FF*206566      JSR FMULT
FA02*A2E3        LDX #LOW FPU2
FA04*A004        LDY #HIGH FPU2
FA06*200D6E      JSR MOVMF

FA09*2023FD      JSR BCALC
FA0C*A99B        LDA #LOW INT11829
FA0E*A064        LDY #HIGH INT11829

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SUBSTITUTE SHEET

```

FA10*2065c6    JSR FMULT
FA13*A2DE      LDX #LOW FPU
FA15*A004      LDY #HIGH FPU
FA17*200D68    JSR MOVMF

FA1A*20B0FD    JSR LINREG20 ;CALC AT 20 MPH??
FA1D*A9A0      LDA #LOW INT23658 ;236.58
FA1F*A064      LDY #HIGH INT23658
FA21*2065c6    JSR FMULT
FA24*A2E8      LDX #LOW FPCR20
FA26*A004      LDY #HIGH FPCR20
FA28*200D68    JSR MOVMF
FA2B*2061FD    JSR RCALC ;DISPLAY R SOMEWHERE????
FA2E*A2C0      LDX #LOW FPARG
FA30*A003      LDY #HIGH FPARG
FA32*200D68    JSR MOVMF
                ;JSR DUMPFDATA
FA35*60        RTS
                ;END DAC 0 CALIBRATION

```

```

FA36*          INCPNT15
FA36*E61E      INC PNT15
FA36*D002      BNE **4
FA3A*E61F      INC PNT15+1
FA3C*A51E      LDA PNT15 ;DONE?
FA3E*C51C      CMP PNT14
FA40*D004      BNE INCPNT15A ;NO
FA42*A51F      LDA PNT15+1
FA44*C51D      CMP PNT14+1

FA46*          INCPNT15A
FA46*60        RTS

                ;START DAC 105 CALCULATION

```

```

FA47*          CALDAC105
FA47*20C5FD    JSR RESCALVAL
FA4A*A9C3      LDA #LOW DACDAT ;SPEEDS
FA4C*851E      STA PNT15
FA4E*A905      LDA #HIGH DACDAT
FA50*851F      STA PNT15+1
FA52*A9A0      LDA #LOW CRSDAT ;VOLTAGES
FA54*851A      STA PNT13
FA56*A90E      LDA #HIGH CRSDAT
FA58*851B      STA PNT13+1

```

```

FA5A*          DAC105F
FA5A*2033F4    JSR RDYFAC
FA5D*A000      LDY #0
FA5F*B11E      LDA (PNT15),Y
FA61*85DA      STA FACLO
FA63*207565    JSR NORMAL
FA66*203B67    JSR DIV10
FA69*A27C      LDX #LOW ARGTMP ;X

```

**SUBSTITUTE SHEET**

FAD7*A2ED	LDX #LOW FPE20
FADC*A004	LDY #HIGH FPE20
FADE*200D68	JSR MOVMF
FAE1*2061FD	JSR RCALC ;DISPLAY SOMEWHERE???
FAE4*A2A2	LDX #LOW FPWIND
FAE6*A004	LDY #HIGH FPWIND
FAE8*200D68	JSR MOVMF
FAEB*2005FD	JSR RESCALVAL
FAEE*A9C3	LDA #LOW DACDAT
FAF0*851E	STA PNT15
FAF2*A9C5	LDA #HIGH DACDAT
FAF4*851F	STA PNT15+1
FAF6*	DAC105L
FAF8*6428	STZ MCAND
FAFB*642F	STZ MCAND+1
FAFA*A000	LDY #0
FAFC*A204	LDX #4
FAFE*	DAC105M
FAFE*18	CLC
FAFF*B11E	LDA (PNT15),Y
FB01*6529	ADC MCAND+1
FB03*8529	STA MCAND+1
FB05*A900	LDA #0
FB07*6528	ADC MCAND
FB09*8528	STA MCAND
FB0B*CA	DEX
FB0C*3008	BMI DAC105N
FB0E*2036FA	JSR INCPNT15
FB11*D0EB	BNE DAC105M
FB13*4C91FB	JMP DAC105R
FB16*	DAC105N
FB16*2033F4	JSR RDYFAC
FB19*A529	LDA MCAND+1
FB1B*85DA	STA FACLO
FB1D*A528	LDA MCAND
FB1F*85D9	STA FACMO
FB21*207565	JSR NORMAL
FB24*A266	LDX #LOW FACTMP1
FB26*A003	LDY #HIGH FACTMP1
FB28*200D68	JSR MOVMF
FB2B*AD4903	LDA HRTCNT ;1ST READING?
FB2E*D003	BNE *+5
FB30*4C7BFB	JMP DAC105P ;YES
FB33*A96D	LDA #LOW FACTMP2 ;LAST READ
FB35*A003	LDY #HIGH FACTMP2
FB37*20ED64	JSR FSUB
FB3A*A9A5	LDA #LOW INT033 ;.033333 1/(5*.12*10*5)
FB3C*A064	LDY #HIGH INT033
FB3E*206566	JSR FMULT
FB41*A263	LDX #LOW FACTMP ;Y
FB43*A003	LDY #HIGH FACTMP
FB45*200D68	JSR MOVMF

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 v1.93L Page 1  
Module: E171A

```

FB49>A969      LDA #LOW FACTMP1
FB4A>A003      LDY #HIGH FACTMP1
FB4C>200F67    JSR MOVFM
FB4F>A96D      LDA #LOW FACTMP2
FB51>A003      LDY #HIGH FACTMP2
FB53>200445    JSR FADD
FB56>204568    JSR MOVAF
FB59>A919      LDA #LOW INT100 ;2*5*10
FB5E>A064      LDY #HIGH INT100
FB5D>200F67    JSR MOVFM
FB60>20E4FD    JSR FPDIV
FB63>A27C      LDX #LOW ARGTMP ;X
FB65>A003      LDY #HIGH ARGTMP
FB67>200D68    JSR MOVMF
FB6A>A963      LDA #LOW FACTMP
FB6C>A003      LDY #HIGH FACTMP
FB6E>206566    JSR FMULT
FB71>A263      LDX #LOW FACTMP ;Y
FB73>A003      LDY #HIGH FACTMP
FB75>200D68    JSR MOVMF
FB78>2038FC    JSR LINREG

FB7B*          DAC105F
FB7B>A204      LDX #4

FB7D*          DAC105Q ;THIS READ TO LAST READING
FB7D>B06803    LDA FACTMP1,X
FB80>9D6D03    STA FACTMP2,X
FB83>CA        DEX
FB84>10F7      BPL DAC105Q
FB86>EE4903    INC HRTCNT ;NUMBER OF POINTS
FB89>2036FA    JSR INCPNT15 ;NEXT POINT
FB8C>F003      BEQ DAC105R ;DONE
FB8E>4CF6FA    JMP DAC105L ;NEXT AVG

FB91*          DAC105R
FB91>2033F4    JSR RDYFAC
FB94>CE4903    DEC HRTCNT
FB97>AD4903    LDA HRTCNT
FB9A>85DA      STA FACLO
FB9C>20B6FC    JSR ACALC
FB9F>2023FD    JSR BCALC
FBA2>20B0FD    JSR LINREG20
FBA5>A99B      LDA #LOW INT11829
FBA7>A064      LDY #HIGH INT11829
FBA9>206566    JSR FMULT
FBAC>204568    JSR MOVAF
FBAF>A9E8      LDA #LOW FPFR20
FBB1>A004      LDY #HIGH FPFR20
FBB3>20DF67    JSR MOVFM
FBB6>20F064    JSR FSUBT
FBB9>A9ED      LDA #LOW FPE20
FBBB>A004      LDY #HIGH FPE20
FBBD>20C966    JSR CONUPK

```

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```

FBC0*20EAF0      JSR FFDIV
FBC3*204569      JSR MOVAF
FBC6*A9AA      LDA #LOW INT6029 ;0.6029
FBC8*A004      LDY #HIGH INT6029
FBCA*20DF67      JSR MOVFM
FBCD*20EAF0      JSR FFDIV
FBD0*A2F2      LDX #LOW FPM
FBD3*A004      LDY #HIGH FPM
FBD4*200D08      JSR MOVFM
*FBD7*2001FD      JSR RCLC ;DISPLAY SOMEWHERE???

```

```

FBDA*           DAC105RA
FBDA*206BA3      JSR CLRDSP
FBDD*20ABA3      JSR DSPONC
FBE0*A920      LDA #$20
FBE2*8501      STA ADDR+1
FBE4*6400      STZ ADDR
FBE6*A9DE      LDA #LOW FPV
FBE8*A004      LDY #HIGH FPV
FBEA*206DFE      JSR FLTPRT
FBED*A921      LDA #$21
FBEF*8501      STA ADDR+1
FBF1*A9E3      LDA #LOW FPV2
FBF3*A004      LDY #HIGH FPV2
FBF5*206DFE      JSR FLTPRT
FBF8*A922      LDA #$22
FBFA*8501      STA ADDR+1
FBFC*A9F2      LDA #LOW FPM
FBFE*A004      LDY #HIGH FPM
FC00*206DFE      JSR FLTPRT
FC03*A923      LDA #$23
FC05*8501      STA ADDR+1
FC07*A9CA      LDA #LOW FPARG
FC09*A003      LDY #HIGH FPARG
FC0B*206DFE      JSR FLTPRT
FC0E*A924      LDA #$24
FC10*8501      STA ADDR+1
FC12*A9A2      LDA #LOW FPWIND
FC14*A004      LDY #HIGH FPWIND
FC16*206DFE      JSR FLTPRT
FC19*A925      LDA #$25
FC1B*8501      STA ADDR+1
FC1D*A9D9      LDA #LOW FPR
FC1F*A004      LDY #HIGH FPR
FC21*206DFE      JSR FLTPRT
*FC24*2068BE      JSR BEEP
                  ;JSR DUMPDATA
FC27*A9FC      LDA #LOW M81 ;"MAIN MENU"
*FC29*A042      LDY #HIGH M81
FC2B*20E7DA      JSR INVMSC1

```

```

FC2E*           DAC105RB
FC2E*207CA5      JSR KEYIN ;^FOR NOW
FC31*C911      CMP #$11
FC33*D0F9      BNE DAC105RB

```

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Huntsville Macro Assembler \$5002 cross assembler for

-DOS 2.0 v1.82L Page :

Module: E:FILE

FC35\*4C4081

JMF MM

;DAC 105 CALCULATION DONE

FC3E\*

LINE05 ;RUNNING LINEAR REGRESSION

FC3E\*A97C

LDA #LOW ARGTMP ;X

FC3A\*A003

LDY #HIGH ARGTMP

FC3C\*20DF67

JSR MOVFM

FC3F\*A963

LDA #LOW FACTMP ;Y

FC41\*A003

LDY #HIGH FACTMP

FC43\*206566

JSR FMULT

FC46\*A901

LDA #LOW FPSUMXY

FC48\*A005

LDY #HIGH FPSUMXY

FC4A\*200465

JSR FADD

FC4D\*A201

LDX #LOW FPSUMXY

FC4F\*A005

LDY #HIGH FPSUMXY

FC51\*200D68

JSR MOVFM

FC54\*A97C

LDA #LOW ARGTMP ;X

FC56\*A003

LDY #HIGH ARGTMP

FC58\*20DF67

JSR MOVFM

FC5B\*A9F7

LDA #LOW FPSUMX

FC5D\*A004

LDY #HIGH FPSUMX

FC5F\*200465

JSR FADD

FC62\*A2F7

LDX #LOW FPSUMX

FC64\*A004

LDY #HIGH FPSUMX

FC66\*200D68

JSR MOVFM

FC69\*A97C

LDA #LOW ARGTMP ;X

FC6B\*A003

LDY #HIGH ARGTMP

FC6D\*20DF67

JSR MOVFM

FC70\*A97C

LDA #LOW ARGTMP

FC72\*A003

LDY #HIGH ARGTMP

FC74\*206566

JSR FMULT ;X^2

FC77\*A906

LDA #LOW FPSUMXX

FC79\*A005

LDY #HIGH FPSUMXX

FC7B\*200465

JSR FADD

FC7E\*A206

LDX #LOW FPSUMXX

FC80\*A005

LDY #HIGH FPSUMXX

FC82\*200D68

JSR MOVFM

FC85\*A963

LDA #LOW FACTMP ;Y

FC87\*A003

LDY #HIGH FACTMP

FC89\*20DF67

JSR MOVFM

FC8C\*A9FC

LDA #LOW FPSUMY

FC8E\*A004

LDY #HIGH FPSUMY

FC90\*200465

JSR FADD

FC93\*A2FC

LDX #LOW FPSUMY

FC95\*A004

LDY #HIGH FPSUMY

FC97\*200D68

JSR MOVFM

FC9A\*A963

LDA #LOW FACTMP ;Y

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FC9C*A003	LDA #HIGH FACTMP
FC9E*20DF67	JSR MOVFM
FCA1*A963	LDA #LOW FACTMP
FCA3*A003	LDY #HIGH FACTMP
FCA5*206566	JSR FMULT
*FCA8*A90B	LDA #LOW FPSUMYY
FCAA*A005	LDY #HIGH FPSUMYY
FCAC*200465	JSR FADD
FCAF*A20E	LDX #LOW FPSUMYY
*FCB1*A005	LDY #HIGH FPSUMYY
FCB3*4C0D68	JMP MOVMF
FCB6*	ACALC ;CALCULATE "A" (Y = AX + B)
FCB6*207565	JSR NORMAL ;NORMALIZE "N"
FCB8*A363	LDX #LOW FACTMP
FCBB*A003	LDY #HIGH FACTMP
FCBD*200D68	JSR MOVMF
FCC0*A9F7	LDA #LOW FPSUMX
FCC2*A004	LDY #HIGH FPSUMX
FCC4*20DF67	JSR MOVFM
FCC7*A9FC	LDA #LOW FPSUMY
FCC9*A004	LDY #HIGH FPSUMY
FCCB*206566	JSR FMULT
FCCE*204568	JSR MOVAF
FCD1*A963	LDA #LOW FACTMP ;N
FCD3*A003	LDY #HIGH FACTMP
FCD5*20DF67	JSR MOVFM
FCD8*20EAFD	JSR FPDIV
FCD8*A901	LDA #LOW FPSUMXY
FCDD*A005	LDY #HIGH FPSUMXY
FCDF*20ED64	JSR FSUB
FCE2*A272	LDX #LOW FACTMP3 ;STORE
FCE4*A003	LDY #HIGH FACTMP3
FCE6*200D68	JSR MOVMF
FCE9*A9F7	LDA #LOW FPSUMX
FCEB*A004	LDY #HIGH FPSUMX
FCED*20DF67	JSR MOVFM
FCF0*A9F7	LDA #LOW FPSUMX
FCF2*A004	LDY #HIGH FPSUMX
FCF4*206566	JSR FMULT
FCF7*204568	JSR MOVAF
FCFA*A963	LDA #LOW FACTMP ;N
FCFC*A003	LDY #HIGH FACTMP
FCFE*20DF67	JSR MOVFM
*FD01*20EAFD	JSR FPDIV
FD04*A906	LDA #LOW FPSUMXX
FD06*A005	LDY #HIGH FPSUMXX
*FD08*20ED64	JSR FSUB
FD0B*A277	LDX #LOW FACTMP4 ;STORE
FD0D*A003	LDY #HIGH FACTMP4
FD0F*200D68	JSR MOVMF
FD12*A972	LDA #LOW FACTMP3
FD14*A003	LDY #HIGH FACTMP3
FD16*20C966	JSR CONUPK

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```
FD19*20EAFD    JSR FPDIV
FD1C*A2CF      LDX #LOW FPA ;STORE
FD1E*A004      LDY #HIGH FPA
FD20*4C0D68    JMP MOVFM
```

```
FD23*          BCALC ;CALCULATE "B" (Y = AX + B)
FD23*A9FC      LDA #LOW FPSUMY
FD25*A004      LDY #HIGH FPSUMY
FD27*20C966    JSR CONUPK
FD2A*A963      LDA #LOW FACTMP ;N
FD2C*A003      LDY #HIGH FACTMP
FD2E*20DF67    JSR MOVFM
FD31*20EAFD    JSR FPDIV
FD34*A26D      LDX #LOW FACTMP2
FD36*A003      LDY #HIGH FACTMP2
FD38*200D68    JSR MOVFM
FD3E*A9F7      LDA #LOW FPSUMX
FD3D*A004      LDY #HIGH FPSUMX
FD3F*20C966    JSR CONUPK
FD42*A963      LDA #LOW FACTMP ;N
FD44*A003      LDY #HIGH FACTMP
FD46*20DF67    JSR MOVFM
FD49*20EAFD    JSR FPDIV
FD4C*A9CF      LDA #LOW FPA
FD4E*A004      LDY #HIGH FPA
FD50*206566    JSR FMULT
FD53*A96D      LDA #LOW FACTMP2
FD55*A003      LDY #HIGH FACTMP2
FD57*20ED64    JSR FSUB
FD5A*A2D4      LDX #LOW FPB ;STORE
FD5C*A004      LDY #HIGH FPB
FD5E*4C0D68    JMP MOVFM
```

```
FD61*          RCALC ;CALCULATE CORRELATION COEFFICIENT
FD61*A972      LDA #LOW FACTMP3
FD63*A003      LDY #HIGH FACTMP3
FD65*20DF67    JSR MOVFM
FD68*A972      LDA #LOW FACTMP3
FD6A*A003      LDY #HIGH FACTMP3
FD6C*206566    JSR FMULT
FD6F*A268      LDX #LOW FACTMP1 ;STORE
FD71*A003      LDY #HIGH FACTMP1
FD73*200D68    JSR MOVFM
FD76*A9FC      LDA #LOW FPSUMY
FD78*A004      LDY #HIGH FPSUMY
FD7A*20DF67    JSR MOVFM
FD7D*A9FC      LDA #LOW FPSUMY
FD7F*A004      LDY #HIGH FPSUMY
FD81*206566    JSR FMULT
FD84*204568    JSR MOVAF
FD87*A963      LDA #LOW FACTMP ;N
FD89*A003      LDY #HIGH FACTMP
FD8B*20DF67    JSR MOVFM
FD8E*20EAFD    JSR FPDIV
FD91*A90B      LDA #LOW FPSUMYY
```

```

FD93*A005      LDY #HIGH FPSUMYY
FD95*20ED64     JSR FSUB

FD98*A977      LDA #LOW FACTMP4
FD9A*A003      LDY #HIGH FACTMP4
FD9C*206566     JSR FMULT
FD9F*A968      LDA #LOW FACTMP1
FDA1*A003      LDY #HIGH FACTMP1
FDA3*20C966     JSR CONUFX
FDA6*20EAFD     JSR FPDIV
FDA9*A2D9      LDX #LOW FPR ;STORE
FDAB*A004      LDY #HIGH FPR
FDAD*4C0D68     JMP MOVMF

FDB0*          LINREG20 ;CALCULATE Y AT 20 MPH
FDB0*A9AF      LDA #LOW INT20
FDB2*A064      LDY #HIGH INT20
FDB4*20DF67     JSR MOVFM
FDB7*A9CF      LDA #LOW FPA
FDB9*A004      LDY #HIGH FPA
FDBB*206566     JSR FMULT
FDBE*A9D4      LDA #LOW FPB
FDC0*A004      LDY #HIGH FPB
FDC2*4C0465     JMP FADD

FDC5*          RESCALVAL ;RESET CALIBRATION VALUES
FDC5*6428      STZ MCAND
FDC7*6429      STZ MCAND+1
FDC9*9CF704     STZ FPSUMX
FDCC*9CFC04     STZ FPSUMY
FDCF*9C0105     STZ FPSUMXY
FDD2*9C0605     STZ FPSUMXX
FDD5*9C0B05     STZ FPSUMYY
FDD8*9C4903     STZ HRTCNT
FDDB*60        RTS

```

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Huntsville Macro Assembler 65001 cross assembler for PC-DOS 2.0 v1.22L Page 1  
Module: E1112

```

;COPYRIGHT 1986 FRONTLINE TECHNOLOGY, INC.
AC43*      RIDCOR ;RIDE COURSE
AC43*2068EE JSR BEEP
AC46*9C4403 STZ TIMTRFLG
AC49*AC1403 LDA RIDLEVEL
AC4C*2080F  BNE RIDCOR3
AC4E*4950   LDA #50
AC50*204403 STA TIMTRFLG ;IGNORE PACK POSITION

```

```

AC53*      RIDCOR3
AC53*20728D JSR LDINITDAC
AC56*9C0A02 STZ STARTFLG
AC59*9C0E02 STZ EXFFLG
AC5C*2003C4 JSR MENU1
AC5F*20A3A5 JSR DSPCR3 ;DISPLAY COURSE
AC62*206BC3 JSR PRTLEVEL
AC65*204403 BIT TIMTRFLG ;TIME TRIAL?
AC68*3003   BMI *-5 ;YES, FORGET PACK POSITION
AC6A*2009EA JSR MENU27
AC6D*200BC7 JSR MENU2SOFT
AC70*648E   STZ DIST
AC72*2088D6 JSR RESVAL
AC75*202E53 JSR RIDCUR3

```

```

AC7E*      RIDCOR4
AC7E*645F   STZ KEY
AC7A*20D3C2 JSR KEYIN1
AC7D*F0FE   BEQ *-3
AC7F*09:1   CMP #11 ;START
AC81*D003   BNE *-5
AC83*4CA4AC JMP RIDCOR5
AC86*0912   CMP #12 ;EXPAND SCREEN
AC88*D003   BNE *-5
AC8A*4C05B0 JMP RIDCOR6
AC8D*0913   CMP #13 ;RESET VALUES
AC8F*D009   BNE RIDCOR4A
AC91*2068BE JSR BEEP
AC94*2088D6 JSR RESVAL
AC97*4C53AC JMP RIDCOR3

```

```

AC9A*      RIDCOR4A
AC9A*0914   CMP #14 ;PREVIOUS MENU
AC9C*D0DA   BNE RIDCOR4 ;INVALID KEY
AC9E*2096C0 JSR CHRLO
ACA1*4CEFB6 JMP RUN

```

```

ACA4*      RIDCOR5 ;START
ACA4*2068BE JSR BEEP
ACA7*AD0A02 LDA STARTFLG
ACAA*F003   BEQ *-5 ;NEW ENTRY
ACAC*4CEBAC JMP RIDCOR5BA
ACAF*2003C4 JSR MENU1 ;REWRITE
ACB2*458E   LDA DIST
ACB4*48     PHA

```

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```
ACB5*20A3A5    JSR D9FCRS
ACB6*68        PLA
ACB9*858E      STA DIST
ACB5*202EE3    JSR RIDCORS
ACB5*201B03    JSR PRTLEVEL
ACC1*204403    BIT TIMTRLFLG ;TIME TRIAL?
ACC4*3A23      BMI **5 ;YES
ACC6*207FEA    JSR MENU28 ;PACK POSITION WITHOUT NAMES
ACC9*200405    JSR MENU1A90FT
ACC0*A980      LDA #80 ;MAKE AVG IN CENTER
ACCE*804603    STA AUGHRT
```

```
ACD1*          RIDCORS5A1
ACD1*78        SEI
ACD2*201111    JSR RESVAL
ACD5*2003EE    JSR UPDATE
ACD8*648E      STZ DIST
ACDA*202EE3    JSR RIDCORS
ACDD*A9FF      LDA #FF
ACDF*800402    STA STARTFLG
ACE2*6473      STZ DGCNT1
ACE4*649E      STZ DISTLAST
ACE6*8013      BRA RIDCORS5B
```

```
ACE8*          RIDCORS5BA
ACE8*A9FF      LDA #FF ;INDICATE NOW RUNNING
ACEA*800A02    STA STARTFLG
ACED*200405    JSR MENU1A90FT
ACF0*204403    BIT TIMTRLFLG
ACF3*3006      BMI **8
ACF5*20BEEA    JSR MENU28CLR
ACF8*207FEA    JSR MENU28
```

```
ACFB*          RIDCORS5BB
ACFB*209FA8    JSR IRGENABLE ;ENABLE T1, CB1, CA1, CA2
ACFE*A909      LDA #9
AD00*8D4903    STA HRTCNT
AD03*9C0E02    STZ EXPFLG ;CLR EXPAND FLG
```

```
AD06*          RIDCORS5AA
AD06*A673      LDX DGCNT1
AD08*BD9E02    LDA GRDHEX,X ;GET GRADE
AD0B*8D4203    STA GRADE
AD0E*2019BA    JSR HEXASC5HRT
AD11*A569      LDA ASCI+6
AD13*8D0603    STA GRDASC+1
AD16*A56A      LDA ASCI+7
AD18*8D0703    STA GRDASC+2
AD1B*A673      LDX DGCNT1
AD1D*BDD702    LDA SIGNCX,X
AD20*8D0503    STA GRDASC
AD23*8D2002    STA SIGNN
AD26*C920      CMP #20
AD28*F008      BEQ RIDCORS5A2
AD2A*A980      LDA #80 ;MAKE GRADE NEGATIVE
```

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# SUBSTITUTE SHEET

```

AD94*F01A      BEQ RIDCOR5C
AD96*4543      LDA TIMER2
AD98*0003      BNE **5
AD9A*4C22AE     JMP RIDCOR5D
AD9D*A5A7      LDA TIMER6
AD9F*0003      BNE **5
ADA1*4CF2AF     JMP RIDCOR5H
ADA4*2C1403     BIT TIMTRFLG ;0?
ADAF*309E      BMI RIDCOR5A ;YES, SKIP PACK POS
ADAF*15A5      LDA TIMER4
ADAB*0094      BNE RIDCOR5A
ADAD*4C9BAF     JMP RIDCOR5F

ADE0*          RIDCOR5C
ADE2*4903      LDA #3
ADE2*85A4      STA TIMER3

ADE4*20E1B6     JSR DISTCALC
ADB7*32        SEC
ADB8*A58E      LDA DIST
ADBA*E59E      SBC DISTLAST ;GET DISTANCE SO FAR IN THIS SEGMENT
ADBC*A673      LDX DGCONT1
ADBE*0DB902     CMP DSTHEX,X
ADC1*D059      BNE RIDCOR5C2 ;OK, NOT THERE YET
ADC3*E673      INC DGCONT1
ADC5*9CDF03     STZ DGCONTFLG
ADC8*A673      LDX DGCONT1
ADCA*E472      CFX DGCONT
ADCC*D003      BNE **5 ;OK, NOT COMPLETELY DONE
ADCE*4C0FE2     JMP RIDCOR14 ;FOR NOW, STOP
ADD1*BD9B02     LDA GRDHEX,X
ADD4*8D4203     STA GRADE
ADD7*2019BA     JSR HEXASC5HRT
ADDA*A569      LDA ASCI+6
ADDC*8D0603     STA GRDASC+1
ADDF*A56A      LDA ASCI+7
ADE1*8D0703     STA GRDASC+2
ADE4*A673      LDX DGCONT1
ADE6*BDD702     LDA SIGNCX,X
ADE9*8D0503     STA GRDASC
ADEC*8D2002     STA SIGNN
ADEE*C920      CMP #20
ADF1*F019      BEQ RIDCOR5C0
ADF3*AD4203     LDA GRADE ;MAKE NEGATIVE
ADF6*0900      ORA #80
ADF8*8D4203     STA GRADE
ADFB*BDD602     LDA SIGNCX-1,X ;WAS LAST SEGMENT POSITIVE?
ADFE*C920      CMP #20
AE00*D00A      BNE RIDCOR5C0 ;NO
AE02*A964      LDA #100 ;YES, LOAD 5 SEC DELAY
AE04*85A6      STA TIMERS
AE06*AD0602     LDA RANDIST
AE09*8D6B05     STA RANDISTSAVE

AE0C*          RIDCOR5C0

```

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Huntsville Macro Assembler 65002 cross assembler for FC-008 2.0 01.83L Page 8  
Module: E014

```

AE0C*209A89    JSR GRADECALC
AE0F*20A5AF    JSR RANDISTCALC

AE12*          RIDCOR501
AE12*18        CLC
AE13*A473      LD> DGONT1
AE15*ED9802    LDA DSTHEN-1,X ;ADD PREVIOUS DISTANCE
AE18*15FE      ADC DISTLAST
AE1A*55FE      STA DISTLAST

AE1C*          RIDCOR502
AE1C*202EB3    JSR RIDCURS
AE1F*4C41AD    JMP RIDCOR5A

AE22*          RIDCOR50
AE22*A5A2      LDA TIMER1
AE24*85A3      STA TIMER2
AE26*20C3BE    JSR UPDATE
AE29*2C4403    BIT TIMTRLFLG ;0?
AE2C*1003      BPL **5
AE2E*4C41AD    JMP RIDCOR5A ;YES, SKIP PACK POSITION

AE31*          RIDCOR500

AE31*18        CLC
AE32*A5A6      LDA TIMERS ;DELAY STILL ON?
AE34*F008      BEQ RIDCOR500A ;NO
AE36*AD0202    LDA PHANTDIST+2
AE39*6D6B05    ADC RANDISTSAVE
AE3C*8006      BRA RIDCOR500B

AE3E*          RIDCOR500A
AE3E*AD0202    LDA PHANTDIST+2
AE41*6D0602    ADC RANDIST

AE44*          RIDCOR500B
AE44*8D0202    STA PHANTDIST+2
AE47*AD0102    LDA PHANTDIST+1
AE4A*6900      ADC #0
AE4C*8D0102    STA PHANTDIST+1
AE4F*AD0002    LDA PHANTDIST
AE52*6900      ADC #0
AE54*8D0002    STA PHANTDIST
AE57*9C0002    STZ DISTDIR ;MAKE POSITIVE TO START
AE5A*36        SEC
AE5B*78        SEI
AE5C*AD5D03    LDA RPMDIST+2
AE5F*ED0202    SEC PHANTDIST+2
AE62*8D0502    STA DISTDIFF+2
AE65*AD5C03    LDA RPMDIST+1
AE68*ED0102    SEC PHANTDIST+1
AE6B*8D0402    STA DISTDIFF+1
AE6E*AD5B03    LDA RPMDIST
AE71*ED0002    SEC PHANTDIST
AE74*8D0302    STA DISTDIFF

```

SUBSTITUTE SHEET

AE77*58	CLI
AE78*B003	BCE ++5
AE7A*4C0CAF	JMP RIDCOR5D5 ;NEGATIVE
AE7D*	RIDCOR5D1
AE7D*38	SEC
AE7E*AD0502	LDA DISTDIFF+2
AE81*E935	SBC #128 ;1320 FEET
AE83*AD0402	LDA DISTDIFF+1
AE85*E905	SBC #5
AE88*AD0302	LDA DISTDIFF
AE8E*E900	SBC #0
AE9D*9005	BCC RIDCOR5D1A
AE9F*A92C	LDA #45
AEA1*4C07B2	JMP PACKDISP0 ;FULL WINDLOAD
AE94*	RIDCOR5D1A
AE94*38	SEC
AE95*AD0502	LDA DISTDIFF+2
AE98*E976	SBC #120 ;120 FEET
AE9A*AD0402	LDA DISTDIFF+1
AE9D*E900	SBC #0
AE9F*AD0302	LDA DISTDIFF
AEA2*E900	SBC #0
AEA4*9005	BCC RIDCOR5D2
AEA6*A92E	LDA #43
AEA8*4C07B2	JMP PACKDISP0 ;FULL WINDLOAD
AEAE*	RIDCOR5D2
AEAE*38	SEC
AEAC*AD0502	LDA DISTDIFF+2
AEAF*E964	SBC #100 ;100 FEET
AEB1*AD0402	LDA DISTDIFF+1
AEB4*E900	SBC #0
AEB6*AD0302	LDA DISTDIFF
AEB9*E900	SBC #0
AEBB*9005	BCC RIDCOR5D2A
AEBD*A927	LDA #39
AEBF*4C0CB2	JMP PACKDISP
AEC2*	RIDCOR5D2A
AEC2*38	SEC
AEC3*AD0502	LDA DISTDIFF+2
AEC6*E950	SBC #80 ;80 FEET
AEC8*AD0402	LDA DISTDIFF+1
AECB*E900	SBC #0
AECD*AD0302	LDA DISTDIFF
AED0*E900	SBC #0
AED2*9005	BCC RIDCOR5D3
AED4*A926	LDA #38
AED6*4C0CB2	JMP PACKDISP
AED9*	RIDCOR5D3
AED9*38	SEC
AEDA*AD0502	LDA DISTDIFF+2

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Huntsville Macro Assembler 65002 cross assembler for PC-200 2.0 v1.82L Page 1  
Module: B1-1-

```

AEDD*E93C      SEC #60 ;60 FEET
AEDF*AD0402     LDA DISTDIFF+1
AEE2*E900      SBC #0
AEE4*AD0302     LDA DISTDIFF
AEE7*E900      SBC #0
AEE9*9005      BCC RIDCOR5D3A
AEEF*4925      LDA #37
AEED*4C0CE2     JMP PACKDISP

AEF0*          RIDCOR5D3A
AEF0*38        SEC
AEF1*AD0502     LDA DISTDIFF+2
AEF4*E920      SBC #40 ;40 FEET
AEF6*AD0402     LDA DISTDIFF+1
AEF9*E900      SEC #0
AEFB*AD0302     LDA DISTDIFF
AEFE*E900      SBC #0
AF00*9005      BCC RIDCOR5D4
AF02*A924      LDA #36
AF04*4C0CB2     JMP PACKDISP

AF07*          RIDCOR5D4
AF07*A923      LDA #35 ;LESS THAN 40 FEET
AF09*4C0CB2     JMP PACKDISP

AF0C*          RIDCOR5D5
AF0C*38        SEC
AF0D*AD0502     LDA DISTDIFF+2
AF10*E9D8      SBC #D8 ; -1320 FEET
AF12*AD0402     LDA DISTDIFF+1
AF15*E9FA      SBC #FA
AF17*AD0302     LDA DISTDIFF
AF1A*E9FF      SBC #FF
AF1C*B005      BCS RIDCOR5D5A
AF1E*A919      LDA #25 ; >1320 FEET OFF
AF20*4C07B2     JMP PACKDISP0 ;FULL WINDLOAD

AF23*          RIDCOR5D5A
AF23*38        SEC
AF24*AD0502     LDA DISTDIFF+2
AF27*E986      SBC #86 ; -120 FEET
AF29*AD0402     LDA DISTDIFF+1
AF2C*E9FF      SBC #FF
AF2E*AD0302     LDA DISTDIFF
AF31*E9FF      SBC #FF
AF33*B005      BCS RIDCOR5D6
AF35*A91B      LDA #27 ; >120 FEET OFF
AF37*4C07B2     JMP PACKDISP0 ;FULL WINDLOAD

AF3A*          RIDCOR5D6
AF3A*38        SEC
AF3B*AD0502     LDA DISTDIFF+2
AF3E*E99C      SBC #9C ; -100 FEET
AF40*AD0402     LDA DISTDIFF+1
AF43*E9FF      SBC #FF

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```

AF45*AD0302    LDA DISTDIFF
AF48*E9FF      SBC #FF
AF4A*B005      BCS RIDCOR5D6A
AF4C*A91F      LDA #31
AF4E*4C8CB2    JMP PACKDISP

AF51*          RIDCOR5D6A
AF51*38        SEC
AF52*AD0502    LDA DISTDIFF+2
AF53*E9E0      SBC #E0 ; -80 FEET
AF57*AD0402    LDA DISTDIFF+1
AF5A*E9FF      SBC #FF
AF5C*AD0302    LDA DISTDIFF
AF5F*E9FF      SBC #FF
AF61*B005      BCS RIDCOR5D7
AF63*A920      LDA #32
AF65*4C8CB2    JMP PACKDISP

AF68*          RIDCOR5D7
AF68*38        SEC
AF69*AD0502    LDA DISTDIFF+2
AF6C*E9C4      SBC #C4 ; -60 FEET
AF6E*AD0402    LDA DISTDIFF+1
AF71*E9FF      SBC #FF
AF73*AD0302    LDA DISTDIFF
AF76*E9FF      SBC #FF
AF7E*B005      BCS RIDCOR5D7A
AF7A*A921      LDA #33
AF7C*4C8CB2    JMP PACKDISP

AF7F*          RIDCOR5D7A
AF7F*38        SEC
AF80*AD0502    LDA DISTDIFF+2
AF83*E9D8      SBC #D8 ; -40 FEET
AF85*AD0402    LDA DISTDIFF+1
AF88*E9FF      SBC #FF
AF8A*AD0302    LDA DISTDIFF
AF8D*E9FF      SBC #FF
AF8F*B005      BCS RIDCOR5D8
AF91*A922      LDA #34
AF93*4C8CB2    JMP PACKDISP

AF96*          RIDCOR5D8
AF96*A923      LDA #35 ; LESS THAN 40 FEET BEHIND
AF98*4C8CB2    JMP PACKDISP

AF9B*          RIDCOR5F ; CALCULATE PACK POSITION
AF9B*A917      LDA #23
AF9D*B5A5      STA TIMER4
AF9F*20A5AF    JSR RANDISTCALC
AFA2*4C41AD    JMP RIDCOR5A

AFA5*          RANDISTCALC
AFA5*AD5D03    LDA RPDIST+2
AFA8*2907      AND #7

```

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Huntsville Macro Assembler 65102 cross assembler for PC-DOS 2.0 v1.21 Page 3  
Module: EDIR1A

```

AFAD*0A      ASL A ;*2
AFAE*AA      TAX
AFAC*BDE45E  LDA MULTADDF,X
AFAF*8570     STA INDEX4
AFB1*BDE55E  LDA MULTADDR+1,X
AFB4*8571     STA INDEX4+1
AFB6*2033F4   JSR RDTFAC
AFB8*AD1403   LDA RIDLEVEL
AFEC*39       SEC
AFED*E921     SBC #1 ;MAKE 0-9
AFEE*0A      ASL A ;*16 (FOR 16 GRADES)
AFC0*0A      ASL A
AFC1*0A      ASL A
AFC2*0A      ASL A
AFC3*8585     STA ASAVE3
AFC5*414203   LDA GRADE
AFC8*297F     AND #17F
AFCA*18       CLC
AFCB*658E     ADC ASAVE3
AFCD*AA       TAX
AFCE*AD2002   LDA SIGNN
AFD1*C92D     CMP #'-' ;NEGATIVE?
AFD3*F018     BEQ RIDCOR5G2

AFD5*         RIDCOR5G
AFD5*BDE25E   LDA BASEDISTP,X

AFD8*         RIDCOR5G1
AFD8*85DA     STA FACLO
AFDA*209965   JSR NORMAL
AFDD*A570     LDA INDEX4
AFDF*A471     LDY INDEX4+1
AFE1*208966   JSR FMULT
AFE4*20F868   JSR QINT
AFE7*A5DA     LDA FACLO
AFE9*8D0602   STA RANDIST
AFEC*60       RTS

AFED*         RIDCOR5G2 ;NEGATIVE SLOPE
AFED*BD725C   LDA BASEDISTN,X
AFF0*80E6     BRA RIDCOR5G1

AFF2*         RIDCOR5H
AFF2*A906     LDA #6
AFF4*85A7     STA TIMER6

AFF6*20078A   JSR SPEEDDIV10
AFF9*20BD89   JSR WINDCALC
AFFC*206E89   JSR POWERCALC
AFFF*20198A   JSR DACCALC

B002*4C41AD   JMP RIDCOR5A

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```

B005*      RIDCOR6 ;EXPAND
B005*20:8EE      JSR BEEP
B008*200304      JSR MENU1
B00E*20:813      JSR PRTLEVEL
B00E*A9FF      LDA #$FF
B010*210502      STA EXPFLG
+
B015*AD0402      LDA STARTFLG
B016*F003      BEQ *+5 ;NEW ENTRY
B018*4056B0      JMP RIDCOR6A0
B01E*70      SEI
B01C*2089D6      JSR RESVAL
B01F*20C3BE      JSR UPDATE
B022*58      CLI ;^
B023*640E      STZ PNT7 ;ARTIFICIALLY LOAD PNT7 IN MIDDLE OF SCREEN FOR 2L-CURR
B025*A92C      LDA #$2C ;30
B027*850F      STA PNT7+1
B029*20A3A5      JSR DSPCRS
B02C*648E      STZ DIST
B02E*6499      STZ DIST5
B030*58      CLI
B031*202EB3      JSR RIDCURS
B034*A9FF      LDA #$FF
B036*8D0A02      STA STARTFLG
B039*6473      STZ DGCNT1
B03E*9CDF03      STZ DGCNTFLG
B03E*64FE      STZ DISTLAST
B040*AD9B02      LDA GRDHEX ;GET 1ST GRADE
B043*8D4203      STA GRADE
B046*2019BA      JSR HEXASCShRT .....
B049*A569      LDA ASCI+6
B04E*8D0603      STA GRDASC+1
B04E*A56A      LDA ASCI+7
B050*8D0703      STA GRDASC+2
B053*4C5EB0      JMP RIDCOR6A1

B056*      RIDCOR6A0
B056*20D8B0      JSR EXPCALC
B059*A9FF      LDA #$FF
B05B*8D0A02      STA STARTFLG

B05E*      RIDCOR6A1
B05E*2C4403      BIT TIMTRLFLG ;TIME TRIAL?
B061*3006      BMI *+8 ;YES
B063*20BEEA      JSR MENU26CLR
B066*2009EA      JSR MENU27

B069*      RIDCOR6AA
B069*20B3C5      JSR MENU1HSoft
;^STZ MMFLG ;FOR SCROLL

B06C*      RIDCOR6A
B06C*645F      STZ KEY
B06E*20D3C2      JSR KEYIN1
B071*F0FB      BEQ *-3

```

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 .01.82L Page  
Module: E1:1F

```

B073*0911      CMP #11 ;START
B075*0003      BNE ++5
B077*4000B1     JMP RIDCOR11
B07A*0913      CMP #13 ;RESET VALUES
B07C*0003      BNE ++5
B07E*40B0B0     JMP RIDCOR6AT
B081*0912      CMP #12 ;PREVIOUS MENU
B083*0003      BNE ++5 ;^TEST
                ;BNE RIDCOR6A ;INVALID KEY
B085*4032B1     JMP RIDCOR7

B08E*0914      CMP #14
B08A*00E0      BNE RIDCOR6A
                ;^TEST

B08C*2068EE     JSF BEEF
B08F*20C205     BIT MMFLG ;ANY COURSE LEFT?
B092*1005       BPL RIDCOR6AZ ;YES
B094*90C205     STZ MMFLG ;RESET TO 0
B097*8017       BRA RIDCOR6AT ;RESET AND RTN

B099*          RIDCOR6AZ
B099*2003C4     JSR MENU1
B09C*2083C5     JSR MENU1HSOFT
B09F*20B5A5     JSR DSPCRS01
                ;BCS RIDCOR6AX ;NOT DONE YET
                ;LDA #FF ;FINISHED
                ;STA MMFLG

B0A2*          RIDCOR6AX
B0A2*206BC3     JSR PRTLEVEL
                ;JSR TEST
B0A5*2C4403     BIT TIMTRLFLG ;TIME TRIAL?
B0A8*3003       BMI ++5 ;YES
B0AA*2009EA     JSR MENU27
B0AD*4C6CB0     JMP RIDCOR6A

B0B0*          RIDCOR6AT ;RESET VALUES
B0B0*2088D6     JSR RESVAL
B0B3*4C05B0     JMP RIDCOR6

B0B6*          RIDCOR6B ;EXPAND WHILE RUNNING
B0B6*2068BE     JSR BEEP
B0B9*2003C4     JSR MENU1
B0BC*2028C5     JSR MENU1BSOFT
B0BF*206BC3     JSR PRTLEVEL
B0C2*A9FF       LDA #FF
B0C4*8D0B02     STA EXPFLG
B0C7*20D8B0     JSR EXPCALC
B0CA*2C4403     BIT TIMTRLFLG ;TIME TRIAL?
B0CD*3006       BMI ++8 ;YES
B0CF*20BEEA     JSR MENU28CLR

```

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B0D2\*207FE4 JSR MENU28  
B0D5\*4006AD JMP RIDCUR5AA

B0D8\* EXPCALC  
B0DE\*2033F4 JSR RDIYFAC  
B0DE\*458E LDA DIST  
B0DD\*95DA STA FACLO  
B0DF\*200065 JSR NORMAL  
B0E1\*204367 JSR MUL10  
B0E5\*A21E LDX #LOW DIST6  
B0E7\*A004 LDY #HIGH DIST6  
B0E9\*203166 JSR MOVMF  
B0EC\*A200 LDX #0  
B0EE\*9C1202 STZ DSTTOT

B0F1\* EXPCALCB  
B0F1\*18 CLC  
B0F2\*BDE902 LDA DSTHEX,X  
B0F5\*6D2202 ADC DSTTOT  
B0F8\*8D2202 STA DSTTOT  
B0FB\*E473 CPX DGCNT1  
B0FD\*F003 BEQ EXPCALCC  
B0FF\*E8 INX  
B100\*D0EF BNE EXPCALCB ;ALWAYS

B102\* EXPCALCC  
B102\*869F STX BYTDIST  
B104\*3E SEC  
B105\*4D2202 LDA DSTTOT  
B108\*E58E SBC DIST  
B10A\*8593 STA DIST3  
B10C\*A204 LDX #4

B10E\* EXPCALCD  
B10E\*B599 LDA DIST5,X  
B110\*9594 STA DIST4,X  
B112\*CA DEX  
B113\*10F9 BPL EXPCALCD

B115\*A58E LDA DIST  
B117\*48 PHA  
B118\*20B5A5 JSR DSPCRS01  
B11B\*68 PLA  
B11C\*858E STA DIST  
B11E\*9C1502 STZ LAPNR  
B121\*6480 STZ NRBYT  
B123\*640E STZ PNT7 ;ARTIFICIALLY LOAD PNT7 IN MIDDLE OF SCREEN FOR BLKCUR  
B125\*A930 LDA #30  
B127\*850F STA PNT7+1  
B129\*A673 LDX DGCNT1  
B12B\*BD0004 LDA SEGADDR+1,X

B12E\*2087B3 JSR RIDCURS0  
B131\*60 RTS

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 v1.82L Page  
Module: E1.1-

```

B132*      RIDCOR7 ;COMPRESS DISPLAY
B132*2068EE JSR BEEP
B135*9C08C2 STZ EXPFLG ;CLR EXPAND FLAG
B138*A5EE   LDA DIST ;SAVE DIST
B13A*48     PHA
B13E*2003C4 JSR MENU1
B13E*20A3A5 JSR DSPCRS
B141*2065C3 JSR PRTLEVEL
B144*2008C7 JSR MENU2SOFT
B147*68     PLA
B148*858E   STA DIST
B14A*205EE1 JSR NORMCALC

B14D*2C4403 BIT TIMTRLFLG ;TIME TRIAL?
B150*3003   BMI **5 ;YES
B152*2009EA JSR MENU27
B155*4C78AC JMP RIDCOR4 ;FOR NOW

B158*      NORMCALC
B158*9C2202 STZ DSTTOT
B15B*6488   STZ NRBYT
B15D*A200   LDX #0

B15F*      NORMCALCA
B15F*E473   CPX DGCNT1
B161*F00D   BEQ NORMCALCB
B163*18     CLC
B164*BDB902 LDA DSTHEX,X
B167*6D2202 ADC DSTTOT
B16A*8D2202 STA DSTTOT
B16D*E8     INX
B16E*D0EF   BNE NORMCALCA ;ALWAYS

B170*      NORMCALCB
B170*A673   LDX DGCNT1
B172*F005   BEQ NORMCALCC ;0, SKIP REST
B174*B0FF03 LDA SEGADDR,X
B177*8588   STA NREYT

B179*      NORMCALCC
B179*20F5B3 JSR RIDCURSB
B17C*60     RTS

B17D*      RIDCOR8 ;STOP
B17D*20B4C3 JSR STOPVAL ;PUT SOME VALUES TO 0
B180*EE0A02 INC STARTFLG ;PUT BACK TO $01
B183*2068BE JSR BEEP
B186*2C0802 BIT EXPFLG
B189*100E   BPL RIDCOR8A
B18B*2C4403 BIT TIMTRLFLG
B18E*3006   BMI **8
B190*20BEEA JSR MENU28CLR
B193*2009EA JSR MENU27
B196*4C69B0 JMP RIDCOR6AA

```

B199*	RIDCOR8A
B199*2C4403	BIT TIMTRLFLG
B19C*3006	BMI **8
B19E*20BEEA	JSR MENU28CLR
B1A1*20B9EA	JSR MENU27
B1A4*20B9C7	JSR MENU29OFT
B1A7*4C784C	JMP RIDCOR4
B1AA*	RIDCOR9 ;BACK TO PREVIOUS MENU
B1AA*4953	LDA #53 ;T1, CA1, CA2, CB1 IR0 OFF
B1AC*6D6E7F	STA \$7F8E
B1AF*20F6D0	JSR CHRLD
B1B2*4CEFB6	JMP RUN
B1B5*	RIDCOR10
B1B5*4953	LDA #53 ;CA1, CA2, CB1 IR0 OFF
B1B7*8D8E7F	STA \$7F8E
B1BA*20B9C5	JSR MENU1H9OFT
B1BD*4C6CB0	JMP RIDCOR6A
B1C0*	RIDCOR11
B1C0*209FAB	JSR IRGENABLE
B1C3*AD0A02	LDA STARTFLG ;PREVIOUSLY RUNNING?
B1C6*F019	BEG RIDCOR11A ;NO
B1C8*A9FF	LDA #\$FF
B1CA*8D0A02	STA STARTFLG ;INDICATE NOW RUNNING
B1CD*2069BE	JSR BEEP
B1D0*2028C5	JSR MENU1B9OFT
B1D3*2C4403	BIT TIMTRLFLG
B1D6*3006	BMI **8
B1D8*20BEEA	JSR MENU28CLR
B1DB*207FEA	JSR MENU28
B1DE*4C06AD	JMP RIDCOR5AA
B1E1*	RIDCOR11A
B1E1*A9FF	LDA #\$FF
B1E3*8D0A02	STA STARTFLG
B1E6*4CB6B0	JMP RIDCOR6B
B1E9*	RIDCOR12 ;BACK TO NORMAL DISPLAY
B1E9*2069BE	JSR BEEP
B1EC*9C0B02	STZ EXPFLG ;CLEAR EXPAND FLAG
B1EF*2003C4	JSR MENU1
B1F2*2004C5	JSR MENU1ASOFT
B1F5*206BC3	JSR PRTLEVEL
B1F8*A58E	LDA DIST ;SAVE DIST
B1FA*48	PHA
B1FB*20A3A5	JSR DSPCRS
B1FE*68	PLA
B1FF*858E	STA DIST
B201*2058B1	JSR NORMCALC
B204*2C4403	BIT TIMTRLFLG ;TIME TRIAL?
B207*3003	BMI **5 ;YES
B209*207FEA	JSR MENU28
B20C*4CFBAC	JMP RIDCOR5BB

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Huntsville Macro Assembler 65C02 cross assembler for PC-DOS 2.0 v1.82L Page  
Module: E11-

```

B20F*      RIDCOR14 ;STOP AT END OF COURSE
B20F*2068EE JSR BEEP
B212*20B4C3 JSR STOPVAL ;PUT SOME VALUES TO 0
B215*20C3EE JSR UPDATE
B216*2045C5 JSR MENU10SOFT ;ERASE SOFTKEYS
B21E*200B02 BIT EXPFLG ;EXPAND?
B21E*1006   BPL RIDCOR14B ;NO
B220*2063C5 JSR MENU1HSOFT
B223*4C2FE2 JMP RIDCOR14C

```

```

B224*      RIDCOR14B
B226*200BC7 JSR MENU2SOFT

```

```

B22F*      RIDCOR14C
B22F*2C4403 BIT TIMTRFLG
B22C*3006   BMI **8
B22E*20BEEA JSR MENU28CLR ;CLR MENU28
B231*2009EA JSR MENU27

```

```

B234*      RIDCOR14D
B234*645F   STZ KEY
B236*20D3C2 JSR KEYIN1
B239*F0FB   BEQ *-3
B23B*C911   CMP #*11 ;START
B23D*D003   BNE **5
B23F*4CA6B2 JMP RIDCOR15
B242*2C0B02 BIT EXPFLG ;EXPAND?
B245*3027   BMI RIDCOR14F ;YES
B247*C912   CMP #*12 ;EXPAND SCREEN
B249*D003   BNE **5
B24B*4C05B0 JMP RIDCOR6
B24E*C913   CMP #*13 ;RESET VALUES
B250*F007   BEQ RIDCOR14E
B252*C914   CMP #*14 ;PREVIOUS MENU
B254*D0DE   BNE RIDCOR14D
B256*4CAAB1 JMP RIDCOR9

```

```

B259*      RIDCOR14E ;RESET VALUES
B259*2068BE JSR BEEP
B25C*9C0A02 STZ STARTFLG
B25F*205BB5 JSR BLKCURS
B262*2088D6 JSR RESVAL
B265*20C3BE JSR UPDATE
B268*202EB3 JSR RIDCURS
B26B*4C34E2 JMP RIDCOR14D

```

```

B26E*      RIDCOR14F
B26E*C913   CMP #*13 ;RESET VALUES
B270*D003   BNE **5
B272*4C7FB2 JMP RIDCOR14G
B275*C912   CMP #*12 ;PREVIOUS MENU
B277*D0BB   BNE RIDCOR14D ;INVALID KEY
B279*2068BE JSR BEEP
B27C*4C53AC JMP RIDCOR3

```

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```
B27F*      RIDCOR14G
B27F*2068EE JSR BEEP
B282*2088D6 JSR RESVAL
B285*9C8A02 STZ STARTFLG
B286*2003C4 JSR MENU1
B28E*20A345 JSR DSPCR3
B28E*206BC3 JSR PRTLEVEL
B291*648E   STZ DIST
B293*6499   STZ DIST5
B295*202EE3 JSR RIDCORS
B296*208305 JSR MENU1HSOFT
B29B*2C4403 BIT TIMTRLFLG
B29E*3003   BMI *+5
B2A0*2009EA JSR MENU27
B2A3*4C34B2 JMP RIDCOR14D
```

```
B2A6*      RIDCOR15 ;START AFTER COURSE ENDED
           ;JSR BEEP
B2A6*9C8A02 STZ STARTFLG
B2A9*2088D6 JSR RESVAL
B2AC*2C0B02 BIT EXPFLG ;EXPAND?
B2AF*3003   BMI *+5 ;YES
B2B1*4CA4AC JMP RIDCOR5
B2B4*4CC0B1 JMP RIDCOR11
```

```
B2B7*      PACKDISP0 ;FULL WINDLOAD
B2B7*9C6905 STZ WINDLOADFLG
B2BA*8005   BRA PACKDISP00
```

```
B2BC*      PACKDISP ;DISPLAY IN PACK POSITION
B2BC*A2FF   LDX #FF
B2BE*8E6905 STX WINDLOADFLG
```

```
B2C1*      PACKDISP00
B2C1*48     PHA ;SAVE POSITION
B2C2*A510   LDA PNT8
B2C4*8500   STA ADDR
B2C6*A511   LDA PNT8+1
B2C8*8501   STA ADDR+1
B2CA*A205   LDX #5
B2CC*A000   LDY #0
```

```
B2CE*      PACKDISP1
B2CE*A900   LDA #0 ;CLEAR EXISTING PACK
B2D0*9100   STA (ADDR),Y
B2D2*CA     DEX
B2D3*F005   BEQ PACKDISP2
B2D5*207FA7 JSR ADD40
B2D8*80F4   BRA PACKDISP1
```

```
B2DA*      PACKDISP2
B2DA*68     PLA ;GET POSITION BACK
B2DB*8500   STA ADDR
B2DD*8510   STA PNT8
```

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Huntsville Macro Assembler 65C02 cross assembler for PC-DOS 2.0 v1.62L Page :  
Module: E:1A

B2DF*A920	LDA #\$20
B2E1*8501	STA ADDR+1
B2E3*A205	LDX #5
B2E5*A000	LDY #0
B2E7*	PACKDISP3
B2E7*A9FF	LDA #\$FF
B2E9*9100	STA (ADDR),Y
B2EB*CA	DEX
B2ED*F005	BEG PACKDISP4
B2EE*207FA7	JSR ADD40
B2F1*80F4	BRA PACKDISP3
B2F3*	PACKDISP4
B2F3*4C41AD	JMP RIDCOR5A

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POWERCALC ;CALCULATE POWER

896E  
896E A99C  
8970 A004  
8972 201F67

LDA #LOW FPGRADE  
LDY #HIGH FPGRADE  
JSR MOVFM

8975 A9A2  
8977 A004  
8979 200465

LDA #LOW FPWIND  
LDY #HIGH FPWIND  
JSR FADD

897C  
897C 24D5  
897E 1004  
8980 90CF03  
8983 60

POWERCALC0  
BIT FACSGN ;NEGATIVE?  
BPL POWERCALC1  
STZ FPPower ;YES, MAKE 0  
RTS

8984  
8984 A98E  
8986 A004  
898E 206566  
898E A9F1  
898D A063  
898F 206566  
8992 A2CF  
8994 A003  
8996 200D68  
8999 60

POWERCALC1  
LDA #LOW FPSPEED  
LDY #HIGH FPSPEED  
JSR FMULT  
LDA #LOW INT0447 ;0.0447 (MPH TO METERS/SEC, DIV BY 10)  
LDY #HIGH INT0447  
JSR FMULT  
LDX #LOW FPPower  
LDY #HIGH FPPower  
JSR MOVFM  
RTS

899A  
899A AD4203  
899D 207568  
89A0 A9D3  
89A2 A063  
89A4 206566  
89A7 A9CE  
89A9 A063  
89AB 200465  
89AE A998  
89B0 A004  
89B2 206566  
89B5 A29D  
89B7 A004  
89B9 200D68  
89BC 60

GRADECALC ;CALCULATE GRADE POWER  
LDA GRADE  
JSR FLOAT  
LDA #LOW INT4448  
LDY #HIGH INT4448  
JSR FMULT  
LDA #LOW INT0178  
LDY #HIGH INT0178  
JSR FADD  
LDA #LOW FPWEIGHT  
LDY #HIGH FPWEIGHT  
JSR FMULT  
LDX #LOW FPGRADE  
LDY #HIGH FPGRADE  
JSR MOVFM  
RTS

89BD  
89BD A998  
89BF A004  
89C1 20DF67  
89C4 A9E7  
89C6 A063  
89C8 206566  
89CB A9E2  
89CD A063

WINDCALC  
LDA #LOW FPWEIGHT  
LDY #HIGH FPWEIGHT  
JSR MOVFM  
LDA #LOW INT205 ;0.0002055556  
LDY #HIGH INT205  
JSR FMULT  
LDA #LOW INT226 ;0.002266667  
LDY #HIGH INT226

Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 v1.32L Page 1  
Module: E111A

```

89CF 200465      JSR FADD
89D2 A263        LDX #LOW FACTMP
89D4 A003        LDY #HIGH FACTMP
89D6 200D68      JSR MOVMP
89D9 A003        LDA #LOW FPSPEED10
89DB A004        LDY #HIGH FPSPEED10
89DD 200966      JSR CONUPK
89DE A9EC        LDA #LOW INT2 ;^2
89E2 A063        LDY #HIGH INT2
89E4 20DF67      JSR MOVFM
89E7 20926B      JSR FPWRT
89EA A963        LDA #LOW FACTMP
89EC A003        LDY #HIGH FACTMP
89EE 206566      JSR FMULT
89F1 AD6905      LDA WINDLOADFLG
89F4 D008        BNE WINDCALC2

89F6            WINDCALC1
89F6 A2A2        LDX #LOW FPWIND
89F8 A004        LDY #HIGH FPWIND
89FA 200D68      JSR MOVMP
89FD 60          RTS

89FE            WINDCALC2
89FE A90F        LDA #LOW INTPT7 ;0.70
8A00 A064        LDY #HIGH INTPT7
8A02 206566      JSR FMULT
8A05 80EF        BRA WINDCALC1

8A07            SPEEDDIV10
8A07 A98E        LDA #LOW FPSPEED
8A09 A004        LDY #HIGH FPSPEED
8A0B 20DF67      JSR MOVFM
8A0E 203B67      JSR DIV10
8A11 A293        LDX #LOW FPSPEED10
8A13 A004        LDY #HIGH FPSPEED10
8A15 200D68      JSR MOVMP
8A18 60          RTS

8A19            PAGE

```

```

BA19          DACCALC ;CALCULATE DAC VALUE AND LOAD
BA19 2033F4    JSR RDYFAC
BA1C AD4A04    LDA ADTOT+1
BA1F 05DA      STA FACLO
BA21 AD4A04    LDA ADTOT
BA24 05DA      STA FACMO
BA26 207565    JSR NORMAL
BA29 A5C4      LDA #LOW INT9765 ;.009765625
BA2B A063      LDY #HIGH INT9765
BA2D 206566    JSR FMULT ;NORMALIZE TO VOLTS
BA30 A2C5      LDX #LOW FPACC
BA32 A003      LDY #HIGH FPACC
BA34 200D68    JSR MOVMF
BA37 A9C5      LDA #LOW FPACC
BA39 A003      LDY #HIGH FPACC
BA3B 206566    JSR FMULT ;^2
BA3E A993      LDA #LOW FPSPEED10 ;SPEED/10
BA40 A004      LDY #HIGH FPSPEED10
BA42 206566    JSR FMULT
BA45 A9F6      LDA #LOW INT1408 ;14.08
BA47 A063      LDY #HIGH INT1408
BA49 206566    JSR FMULT
BA4C A263      LDX #LOW FACTMP
BA4E A003      LDY #HIGH FACTMP
BA50 200D68    JSR MOVMF ;SAVE
BA53 A956      LDA #LOW INT1
BA55 A063      LDY #HIGH INT1
BA57 20C966    JSR CONUPK
BA5A A993      LDA #LOW FPSPEED10
BA5C A004      LDY #HIGH FPSPEED10
BA5E 20DF67    JSR MOVFM
BA61 20EAFD    JSR FPDIV ;1/V
BA64 A937      LDA #LOW INTE
BA66 A064      LDY #HIGH INTE
BA68 20C966    JSR CONUPK
BA6B A5D6      LDA FACEXP ;GET READY FOR FPWRT
BA6D 20926B    JSR FPWRT

BA70 A9FB      LDA #LOW INT12832 ;0.12832
BA72 A063      LDY #HIGH INT12832
BA74 206566    JSR FMULT
BA77 204568    JSR MOVAF
BA7A A900      LDA #LOW INT12903
BA7C A064      LDY #HIGH INT12903
BA7E 20DF67    JSR MOVFM
BA81 20F064    JSR FSUBT
BA84 A963      LDA #LOW FACTMP
BA86 A003      LDY #HIGH FACTMP
BA88 206566    JSR FMULT
BA8B A9F2      LDA #LOW FPM
BA8D A004      LDY #HIGH FPM
BA8F 206566    JSR FMULT
BA92 A263      LDX #LOW FACTMP
BA94 A003      LDY #HIGH FACTMP

```

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Huntsville Macro Assembler e5002 cross assembler for PC-DOS 2.0 v1.92L Page  
Module: E1A1A

```

8A96 200D68      JSR MOVMF

8A99 A993        LDA #LOW FPSPEED10
8A9B A004        LDY #HIGH FPSPEED10
8A9D 200F27      JSR MOVFM
8A9E A90E        LDA #LOW FPV
8A9F A004        LDY #HIGH FPV
8AA0 206566      JSR FMULT
8AA1 A20A        LDA #LOW FPARG
8AA2 A004        LDY #HIGH FPARG
8AA3 200D68      JSR MOVMF ;SAVE
8AA4 A993        LDA #LOW FPSPEED10
8AA5 A004        LDY #HIGH FPSPEED10
8AA6 200F27      JSR MOVFM
8AA7 A993        LDA #LOW FPSPEED10
8AA8 A004        LDY #HIGH FPSPEED10
8AA9 206566      JSR FMULT
8AAB A9E3        LDA #LOW FPV2
8AAC A004        LDY #HIGH FPV2
8AAD 206566      JSR FMULT
8AAE A9CA        LDA #LOW FPARG
8AAF A003        LDY #HIGH FPARG
8AB0 200465      JSR FADD
8AB1 A963        LDA #LOW FACTMP
8AB2 A003        LDY #HIGH FACTMP
8AB3 200465      JSR FADD
8AB4 A255        LDX #LOW FPRPWR ;REAL POWER
8AB5 A004        LDY #HIGH FPRPWR
8AB6 200D68      JSR MOVMF

8AB8          DACCALC9 ;KEEP RUNNING STACK OF 10
8AB9 18          CLC
8ABA A982        LDA #LOW FPRPWRSUM+40
8ABB 8522        STA PNT17
8ABC 6905        ADC #5
8ABD 8520        STA PNT16
8ABE A904        LDA #HIGH FPRPWRSUM+40
8ABF 8523        STA PNT17+1
8AC0 6900        ADC #0
8AC1 8521        STA PNT16+1
8AC2 A208        LDX #8

8AC4          DACCALC10
8AC5 A004        LDY #4

8AC7          DACCALC11
8AC8 B122        LDA (PNT17),Y
8AC9 9120        STA (PNT16),Y
8ACA 86          DEY
8ACB 10F9        BPL DACCALC11
8ACC CA          DEX
8ACD 3013        BMI DACCALC12
8ACE 3E          SEC
8ACF A522        LDA PNT17
8AD0 8520        STA PNT16

```

```

8AF0 E905      SEC #5
8AFE 8522      STA PNT17
8B00 A523      LDA PNT17+1
8B02 8521      STA PNT16+1
8B04 E900      SEC #0
8B06 8523      STA PNT17+1
8B08 80E1      BRA DACCALC10

8B0A          DACCALC12
8B0A A25A      LDX #LOW FPRPWRSUM
8B0C A004      LDY #HIGH FPRPWRSUM
8B0E 200D68    JSR MOVMF

8B11 A9CF      LDA #LOW FPPower
8B13 A003      LDY #HIGH FPPower
8B15 20C966    JSR CONUPK
8B18 20EAFD    JSR FPDIV
8B1E A263      LDX #LOW FACTMP ;SAVE
8B1D A003      LDY #HIGH FACTMP
8B1F 200D68    JSR MOVMF
8B22 A956      LDA #LOW INT1 ;<1?
8B24 A063      LDY #HIGH INT1
8B26 209468    JSR FCOMP
8B29 3008      BMI DACCALC00 ;YES
8B2B AD0C02    LDA DACTMP ;ALREADY AT FULL LOAD?
8B2E C9FF      CMP #$FF
8B30 D001      BNE *+3 ;NO
8B32 60        RTS ;YES. RETURN WITHOUT CHANGING----

8B33          DACCALC00
8B33 A963      LDA #LOW FACTMP
8B35 A003      LDY #HIGH FACTMP
8B37 20DF67    JSR MOVFM
8B3A A9D8      LDA #LOW INT14 ;1.4
8B3C A063      LDY #HIGH INT14
8B3E 209468    JSR FCOMP
8B41 3006      BMI DACCALC0 ;OK, <1.4
                ;JSR BEEP ;^TEST
8B43 A9D8      LDA #LOW INT14 ;LOAD WITH 1.4
8B45 A063      LDY #HIGH INT14
8B47 8004      BRA DACCALC0A

8B49          DACCALC0
8B49 A963      LDA #LOW FACTMP ;GET VALUE BACK
8B4B A003      LDY #HIGH FACTMP

8B4D          DACCALC0A
8B4D 20DF67    JSR MOVFM

8B50 A944      LDA #LOW FPDAC
8B52 A004      LDY #HIGH FPDAC
8B54 206566    JSR FMULT
8B57 A244      LDX #LOW FPDAC
8B59 A004      LDY #HIGH FPDAC
8B5B 200D68    JSR MOVMF

```

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Huntsville Macro Assembler 65C02 cross assembler for PC-DOS 2.0 v1.82L Page :  
Module: B111A

```

8B5E 20E664    JSR FADDH
8B61 20D468    JSR QINT
8B64 A5D8      LDA FACMOH ;>255?
8B66 F004      BEQ DACCALC2 ;MAYBE NOT

8B6E          DACCALC1
8B6E A9FF      LDA #$FF ;LOAD DAC PRETTY HEAVILY
8B6A 8015      BRA DACCALC4

8B6C          DACCALC2 ;TRY NEXT BYTE
8B6C A5D9      LDA FACMO
8B6E D0F8      BNE DACCALC1
8B70 A5D4      LDA FACLO
8B72 D000      BNE DACCALC4
8B74 A204      LDX #4

8B76          DACCALC3
8B76 BDC963    LDA INT10,X
8B79 9D4404    STA FPDAC,X
8B7C CA        DEX
8B7D 10F7      BPL DACCALC3
8B7F A90A      LDA #10

8B81          DACCALC4
8B81 8D0C02    STA DACTMF
8B84 8DA07F    STA $7FA0
8B87 60        RTS

```

```

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92B0*      AUTWRK
92B0*2088D6 JSR RESVAL ;RESET ALL VALUES

92B3*      AUTWRK0
92B3*2068EE JSR BEEP
92B6*203197 JSR LIMITCALC ;CALCULATE UPPER AND LOWER LIMITS
92B9*20D4EA JSR MENU30 ;AUTO TARGET MENU
92BC*20E3A8 JSR DSFONG ;DISPLAY ON

92BF*      AUTWRK1
92BF*207CA5 JSR KEYIN ;READ KEYBOARD
92C2*2068EE JSR BEEP
92C5*0911   CMP #11 ;START
92C7*D003   BNE **5
92C9*4C1D95 JMP AUTOSTART
92CC*C912   CMP #12 ;CHANGE LIMITS
92CE*D003   BNE **5
92D0*4CE792 JMP AUTWRK2
92D3*C913   CMP #13 ;CHANGE MAX
92D5*D003   BNE **5
92D7*4C8D94 JMP AUTWRK3
92DA*C914   CMP #14
92DC*D0E1   BNE AUTWRK1
92DE*9CD17F STZ $7FD:
92E1*2096C0 JSR CHRLO
92E4*4C7587 JMP EXMODE ;PREVIOUS MENU

92E7*      AUTWRK2 ;CHANGE LIMITS
92E7*202FF2 JSR MENU31 ;DISPLAY
92EA*2086F3 JSR MENU32

92ED*      AUTWRK2A
92ED*207CA5 JSR KEYIN ;READ KB
92F0*2068BE JSR BEEP
92F3*C911   CMP #11 ;UPPER LIMIT
92F5*F00D   BEQ AUTWRK2B
92F7*C912   CMP #12 ;LOWER LIMIT
92F9*D003   BNE **5
92FB*4CD493 JMP AUTWRK2J
92FE*C913   CMP #13 ;PREVIOUS MENU
9300*D0EB   BNE AUTWRK2A
9302*80AF   BRA AUTWRK0

9304*      AUTWRK2B ;UPPER LIMIT
9304*A9FF   LDA #$FF
9306*8D1F02 STA DPFLG ;DP NOT ALLOWED

9309*      AUTWRK2B1
9309*A900   LDA #0 ;CLR BLOCK
930B*8DA224 STA $24A2
930E*8DA324 STA $24A3
9311*8DA424 STA $24A4
9314*8DD824 STA $24D8 ;BLINK OFF

```

Appendix

C

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 v1.82L Page 3  
Module: E1-1a

```

9317*8DA924      STA $24A9
931A*4901        LDA #1 ;BLOCK
931C*8DA223      STA $23A2
931F*8DA323      STA $23A3
9322*8DA423      STA $23A4
9325*4902        LDA #2 ;BLINK THESE
9327*8DDF23      STA $23DF
932A*A9A0        LDA #9A0
932C*8DD823      STA $23D8

932F*            AUTWRK2C
932F*207CA5      JSR KEYIN
9332*2068EE      JSR BEEP
9335*C911        CMP #11 ;UPPER LIMIT (AGAIN)
9337*F0D0        BEQ AUTWRK2B:
9339*C912        CMP #12 ;LOWER LIMIT
933B*D003        BNE ++5
933D*4CD493      JMP AUTWRK2J
9340*C913        CMP #13 ;PREVIOUS MENU
9342*D003        BNE ++5
9344*4CE392      JMP AUTWRK0 ;DOES LIMITCALC
9347*C905        CMP #5 ; -
9349*F04D        BEQ AUTWRK2D
934B*C909        CMP #9 ; +
934D*F062        BEQ AUTWRK2G
934F*C93A        CMP #3A
9351*B0D0        BCS AUTWRK2C ;>9
9353*C930        CMP #30
9355*90D8        BCC AUTWRK2C ;<0
9357*46          PHA
935B*A980        LDA #80
935A*8500        STA ADDR
935C*A923        LDA #23
935E*8501        STA ADDR+1
9360*A203        LDX #3
9362*867A        STX XSAVE
9364*A022        LDY #34
9366*847E        STY YSAVE
9368*A200        LDX #0
936A*68          PLA
936B*2065A4      JSR INDT01+3
936E*B094        BCS AUTWRK2B ;INVALID KEY
9370*20A0EA      JSR ASCHEX
9373*AE2702      LDX USERID
9376*18          CLC
9377*BD1005      LDA LOWLIM,X
937A*6905        ADC #5
937C*C56C        CMP HEX+1
937E*B084        BCS AUTWRK2B ;BELOW OR = LOW LIMIT+5
9380*18          CLC
9381*A56C        LDA HEX+1
9383*6905        ADC #5
9385*DD3A05      CMP HRTMAX,X
9388*9003        BCC ++5
938A*4C0493      JMP AUTWRK2B ;ABOVE OR = MAX-5

```

QUANTITATIVE SHEET

```

938D*450C      LDA HEX+1
938F*312505    STA HIGHLIM,X
9393*203197    JSR LIMITCALC
9395*40E792    JMP AUTWRK2

9398*
*9398*4E2702    LDA USERID
939E*18        CLC
939C*BD1005    LDA LOWLIM,X
939F*6905      ADC #5
93A1*002505    CMP HIGHLIM,X
93A4*808F      BCS AUTWRK2C ;AT OR BELOW LOW LIMIT+5
93A7*ED1505    LDA HIGHLIM,X
93A9*28        SEC
93AA*E901      SEC #1
93AC*9D2505    STA HIGHLIM,X
93AF*801A      BRA AUTWRK2G1

93B1*
93B1*4E2702    LDX USERID
93B4*18        CLC
93B5*BD2505    LDA HIGHLIM,X
93B8*6905      ADC #5
93BA*DD3A05    CMP HRTMAX,X
93BD*9003      BCC **5
93BF*4C2F93    JMP AUTWRK2C ;ALREADY AT MAX
93C2*18        CLC
93C3*BD2505    LDA HIGHLIM,X
93C6*6901      ADC #1
93C8*9D2505    STA HIGHLIM,X

93CB*
93CB*203197    JSR LIMITCALC
93CE*2039F3    JSR MENU31A
93D1*4C0993    JMP AUTWRK2B1

93D4*
93D4*A900      AUTWRK2J ;LOWER LIMIT
93D6*8DA223    LDA #0
93D9*8DA323    STA $23A2 ;CLR BLOCK
93DC*8DA423    STA $23A3
93DF*8DD823    STA $23A4
93E2*8DD923    STA $23D8 ;CLR BLINK
*93E5*A901      LDA #1
93E7*8DA224    STA $24A2 ;BLOCK
93EA*8DA324    STA $24A3
93ED*8DA424    STA $24A4
93F0*A9A0      LDA #$A0
93F2*8DD824    STA $24D8
93F5*A902      LDA #2
93F7*8DD924    STA $24D9
93FA*A9FF      LDA #$FF
93FC*8D1F02    STA DPFLG ;NO DP

93FF*
AUTWRK2K

```

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Module: B141A

```

93FF*2070A5    JSR KEYIN
9402*2068EE    JSR BEEP
9405*0911      CMP #11 ;UPPER LIMIT
9407*0003      BNE ++5
9409*400493    JMP AUTWRK2B
940C*0912      CMP #12 ;LOWER LIMIT (AGAIN)
940E*F0EF      BEQ AUTWRK2K
9410*0913      CMP #13 ;PREVIOUS MENU
9412*0003      BNE ++5
9414*40B392    JMP AUTWRK0

9417*0905      CMP #5 ; -
9419*F042      BEQ AUTWRK2M
941E*0909      CMP #9 ; +
941D*F04E      BEQ AUTWRK2N
941F*093A      CMP #3A
9421*B0DC      BCS AUTWRK2K ; >9
9423*0930      CMP #30
9425*90D8      BCC AUTWRK2K ; <0
9427*48        PHA
9428*A980      LDA #80
942A*0500      STA ADDR
942C*A924      LDA #24
942E*8501      STA ADDR+1
9430*A203      LDX #3
9432*867A      STX XSAVE
9434*A022      LDY #34
9436*847E      STY YSAVE
9438*A200      LDX #0
943A*68        PLA
943B*2065A4    JSR INDT01+3
943E*B094      BCS AUTWRK2J ;INVALID KEY
9440*20A0BA    JSR ASCHEX
9443*AE2702    LDX USERID
9446*A56C      LDA HEX+1
9448*F08A      BEQ AUTWRK2J ;0
944A*18        CLC
944B*6905      ADC #5
944D*DD2505    CMP HIGHLIM,X
9450*B002      BCS AUTWRK2J ;AT OR ABOVE HIGH LIMIT-5
9452*A56C      LDA HEX+1
9454*9D1005    STA LOWLIM,X
9457*203197    JSR LIMITCALC
945A*40E792    JMP AUTWRK2

945D*          AUTWRK2M ; -
945D*AE2702    LDX USERID
9460*BD1005    LDA LOWLIM,X
9463*F09A      BEQ AUTWRK2K ;ALREADY 0
9465*38        SEC
9466*E901      SBC #1
9468*9D1005    STA LOWLIM,X
946B*8017      BRA AUTWRK2N1

```

```
946D*      AUTWRK2N ;+
946D*AE2702 LDX USERID
9470*1E     CLC
9471*BD1005 LDA LOWLIM,X
9474*6905   ADC #5
9476*DC3505 CMP HIGHLIM,X
9477*E004   BCS AUTWRK2N ;ALREADY AT HIGH LIMIT-5
947B*18     CLC
947C*BD1005 LDA LOWLIM,X
947F*6901   ADC #1
9481*9D1005 STA LOWLIM,X

9484*      AUTWRK2N1
9484*203197 JSR LIMITCALC
9487*2039F3 JSR MENU31A
948A*4CD493 JMP AUTWRK2J

948D*      AUTWRK3
948D*209EF3 JSR MENU33

9490*      AUTWRK3A
9490*A901   LDA #1
9492*8D9823 STA $2398 ;BLOCK
9495*8D9923 STA $2399
9498*8D9A23 STA $239A
949B*A92A   LDA #$2A
949D*8DD623 STA $23D6
94A0*A9FF   LDA #$FF
94A2*8D1F02 STA DPFLG ;NO DF

94A5*      AUTWRK3E
94A5*207CA5 JSR KEYIN
94A8*2068BE JSR BEEP
94AB*C911   CMP #$11 ;PREVIOUS MENU
94AD*D003   BNE ++5
94AF*4CB392 JMP AUTWRK0

94B2*C905   CMP #5 ;-
94B4*F03A   BEQ AUTWRK3C
94B6*C909   CMP #9 ;+
94B8*F047   BEQ AUTWRK3D
94BA*C93A   CMP #$3A
94BC*B0E7   BCS AUTWRK3E ;>9
94BE*C930   CMP #$30
94C0*90E3   BCC AUTWRK3E ;<0
94C2*48     PHA
94C3*A980   LDA #$80
94C5*8500   STA ADDR
94C7*A923   LDA #$23
94C9*8501   STA ADDR+1
94CB*A203   LDX #3
94CD*867A   STX XSAVE
94CF*A018   LDY #24
94D1*847E   STY YSAVE
94D3*A200   LDX #0
```

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 11.22L Page :  
Module: E1-1A

```

94D5*8E      PLA
94E6*201544   JSR INDT01+3
94D9*E02E     BCS AUTWRK3A ;INVALID KEY
94DE*20A0BA   JSR ASCHEX
94DE*AE1703    LDX USERID
94E1*A50C     LDA HEX+1
94E3*09DD     CMP #221
94E5*E049     BCS AUTWRK3A ;>220
94E7*9D3A05   STA HRTMAX,X
94EA*208D86   JSR UPLOWCALC ;CALCULATE NEW LIMITS
94ED*4CB392   JMP AUTWRK3E

```

```

94F0*        AUTWRK3C ; -
94F0*AE2702   LDX USERID
94F3*8D3A05   LDA HRTMAX,X
94F6*38       SEC
94F7*E901     SBC #1
94F9*9D3A05   STA HRTMAX,X
94FC*208D86   JSR UPLOWCALC ;CALCULATE NEW LIMITS
94FF*8013     BRA AUTWRK3D1

```

```

9501*        AUTWRK3D ; +
9501*AE2702   LDX USERID
9504*ED3A05   LDA HRTMAX,X
9507*09DD     CMP #220
9509*E09A     BCS AUTWRK3E ;ALREADY AT 220
950E*18       CLC
950C*6901     ADC #1
950E*9D3A05   STA HRTMAX,X
9511*208D86   JSR UPLOWCALC ;CALCULATE NEW LIMITS

```

```

9514*        AUTWRK3D1
9514*203197   JSR LIMITCALC
9517*20EDF3   JSR MENU33A
951A*4C9094   JMP AUTWRK3A

```

```

951D*        AUTOSTART ;START AUTO TARGET
951D*20BAED   JSR MENU30ASOFT ;SOFT KEYS
9520*20728D   JSR LDINITDAC ;INITIALIZE A/D, LOAD VALUES IN FLOATING POINT
9523*209FA8   JSR IRQENABLE
9526*9C6F05   STZ INCFLG
9529*9C6E05   STZ DECFLG
952C*9C7005   STZ FACEFLG
952F*A909     LDA #9 ;10 READINGS
9531*8D4903   STA HRTCNT
9534*2057F0   JSR WARMUP ;"WARM-UP"

```

```

9537*        AUTOS1
9537*645F     STZ KEY

```

```

9539*        AUTOS2
9539*2062B7   JSR RPMCALC ;CALCULATE SPEED

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```

953C*20D1E7    JSR CADCALC ;CALCULATE CADENCE
953F*204CE8    JSR HEARTCALC ;CALCULATE HEART RATE
9542*202E8D    JSR ADAUG ;RUNNING TOTAL OF 10 A/D READINGS
9545*45A3      LDA TIMER2 ;1 SEC?
9547*20023     BNE ++5 ;NO
9549*402A95     JMP AUTOS5
954C*45A7      LDA TIMER6 ;0.24 SEC?
954E*2000A     BNE AUTOS2A ;NO
9550*49026     LDA #6 ;RESET
9552*85A7      STA TIMER6
9554*20076A    JSR SPEEDDIV10 ;CALCULATE TRUE SPEED (DIVIDE BY 10)
9557*20198A    JSR DACCALC ;CALCULATE NEW DAC VALUE

955A*          AUTOS2A
955A*455F      LDA KEY ;KB?
955C*F01A      BEQ AUTOS2B ;NO
955E*C911      CMP #11 ;STOP
9560*F010      BEQ AUTOS2A1
9562*C912      CMP #12 ;TURN ON/OFF HEART RATE BEEP
9564*D0D1      BNE AUTOS1
9566*2068BE    JSR BEEP
9569*A202      LDX #2 ;ROW 2
956E*208092    JSR HRSEPTOGGLEL ;TOGGLE HEART RATE BEEP
956E*645F      STZ KEY
9570*8006      BRA AUTOS2B

9572*          AUTOS2A:
9572*20E4C3    JSR STOPVAL ;PUT SOME VALUES TO 0
9575*4CE392    JMP AUTWRK0 ;^??

9578*          AUTOS2B
9578*AD0A02    LDA STARTFLG
957B*D0BC      BNE AUTOS2 ;PAST WARMUP
957D*AD1E03    LDA ELTIMMIN
9580*C902      CMP #2
9582*90B5      BCC AUTOS2 ;NOT 2 MIN YET
9584*206CF0    JSR CLRFACE ;ERASE "WARM UP"
9587*CE0A02    DEC STARTFLG ;=$FF
958A*A955      LDA #LOW FPRPWR ;GET PRESENT POWER
958C*A004      LDY #HIGH FPRPWR
958E*20DF67    JSR MOVFM
9591*203B67    JSR DIV10 ;DIVIDE BY 10
9594*20E664    JSR FADDH ;ROUND
9597*200569    JSR INT ;TO INTEGER
959A*201F67    JSR MUL10 ;MULTIPLY BY 10
959D*A2CF      LDX #LOW FPOWER ;STORE IN POWER
959F*A003      LDY #HIGH FPOWER
95A1*200D68    JSR MOVFM
95A4*8093      BRA AUTOS2

95A6*          AUTOS5 ;1 SEC
95A6*A919      LDA #25 ;RESET
95A8*85A3      STA TIMER2
95AA*208BF0    JSR UPMEN30 ;UPDATE ALL NUMBERS
95AD*AD0A02    LDA STARTFLG ;RUNNING?

```

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 11.82L Page  
Module: E1-1A

```

95E0*3003      BNE AUTOS6 ;YES
95E2*4C3995     JMP AUTOS2

95E5*          AUTOS6
95E5*49AC      LDA #LOW FPHRTAUG ;GET AVG HEART RATE
95E7*4004      LDY #HIGH FPHRTAUG
95E9*20CF67    JSR MOVFM
95EB*49E1      LDA #LOW FFLOWTEST ;COMPARE WITH LOW LIMIT
95ED*4004      LDY #HIGH FFLOWTEST
95EF*20F468    JSR FCOMP ;UNDER LOW LIMIT?
95F1*3003      BMI AUTOS7 ;YES
95F3*4C6F94     JMP AUTOS9 ;CHECK IF ABOVE HIGH

95F6*          AUTOS7
95F6*AD7005    LDA FACEFLG ;FACE ON?
95F8*D005      BNE AUTOS7A ;YES
95FA*AD6E05    LDA DECFLG ;DECREASE ARROW?
95FC*F009      BEQ AUTOS7B ;NO

95FF*          AUTOS7A
95FF*206CF0    JSR CLRFACE ;CLEAR FACE
9601*9C7005    STZ FACEFLG
9603*9C6E05    STZ DECFLG

9606*          AUTOS7B
9606*AD6F05    LDA INCFLG ;INCREASED LAST TIME?
9608*F00A      BEQ AUTOS9 ;NO
960A*AD2C03    LDA SPTIMSEC
960C*C928      CMP #40 ;40 SEC YET?
960E*8003      BCS **5 ;YES
9610*4C3995     JMP AUTOS2

9613*          AUTOS8
9613*9C2C03    STZ SPTIMSEC ;RESET TIMER
9615*9C2D03    STZ SPTIMTNTH

9618*          LDA #FF
961A*8D6F05    STA INCFLG
961C*9C6E05    STZ DECFLG
961E*9C7005    STZ FACEFLG
9620*AD2903    LDA SPDHEX
9622*D00A      BNE AUTOS8AA
9624*AD2A03    LDA SPDHEX+1
9626*C950      CMP #80 ;< 8 MPH?
9628*B003      BCS AUTOS8AA ;NO
962A*4CDD96    JMP AUTOS11AA ;DECREASE LOAD

962D*          AUTOS8AA
962D*A9FF      LDA #FF
962F*CD0C02    CMP DACTMP ;DAC FULL?
9631*F010      BEQ AUTOS8A ;YES
9633*A9CF      LDA #LOW FPPower ;POWER < 1000?
9635*4003      LDY #HIGH FPPower
9637*20DF67    JSR MOVFM
9639*A91E      LDA #LOW INT1000

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```

961A*2064      LDY #HIGH INT1000
961C*209468     JSR FCOMP
961F*3006      EMI AUTOS8E ;YES

9621*          AUTOS8A
9623*201FEF     JSR INCREASEEFFORT

9624*4C3995     JMP AUTOS2

9627*          AUTOS8E
9627*A9AC      LDA #LOW FPHRTAUG
9629*A004      LDY #HIGH FPHRTAUG
962E*20DF67     JSR MOVFM
962E*A9B1      LDA #LOW FPLOWTEST
9630*A004      LDY #HIGH FPLOWTEST
9632*20ED64     JSR FSUB ;GET DIFFERENCE IN HEART RATE
9635*203B67     JSR DIV10 ;DIVIDE BY 10
9638*20E664     JSR FADDH ;ROUND
963E*200569     JSR INT ;TO INTEGER
963E*A263      LDX #LOW FACTMP ;SAVE
9640*A003      LDY #HIGH FACTMP
9642*200D68     JSR MOVFM
9645*A956      LDA #LOW INT1 ;<1?
9647*A063      LDY #HIGH INT1
9649*209468     JSR FCOMP
964C*1006      BPL AUTOS8C ;NO
964E*A956      LDA #LOW INT1 ;USE 1
9650*A063      LDY #HIGH INT1
9652*8004      BRA AUTOS8D

9654*          AUTOS8C
9654*A963      LDA #LOW FACTMP ;GET BACK
9656*A003      LDY #HIGH FACTMP

9658*          AUTOS8D
9658*20DF67     JSR MOVFM
965B*201F67     JSR MUL10 ;MULTIPLY BY 10

965E*A9CF      LDA #LOW FPPower ;INCREASE THAT AMOUNT
9660*A003      LDY #HIGH FPPower
9662*200465     JSR FADD
9665*A2CF      LDX #LOW FPPower ;SAVE
9667*A003      LDY #HIGH FPPower
9669*200D68     JSR MOVFM
966C*4C3995     JMP AUTOS2

966F*          AUTOS9 ;CHECK FOR ABOVE LIMIT
966F*A9AC      LDA #LOW FPHRTAUG
9671*A004      LDY #HIGH FPHRTAUG
9673*20DF67     JSR MOVFM
9676*A9BE      LDA #LOW FPHIGHTST5 ;> UPPER LIMIT + 5?
9678*A004      LDY #HIGH FPHIGHTST5
967A*209468     JSR FCOMP
967D*C901      CMP #1
967F*D003      BNE **5

```

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Module: E1114

```

9681*4C2097      JMP AUTOS13 ;YES

9684*49AC      LDA #LOW FPHRTAUG
9685*4004      LDY #HIGH FPHRTAUG
9686*20DF67     JSR MOVFM
968E*49E6      LDA #LOW FPHIGHTEST
968D*4004      LDY #HIGH FPHIGHTEST
968F*2094c8     JSR FCOMP ;OVER LIMIT?
9692*0901      CMP #1
9694*F01C      BEQ AUTOS10 ;YES
9696*AD7005     LDA FACEFLG ;HAPPY FACE ALREADY ON?
9699*000E      BNE AUTOS9A ;YES
969E*20C9ED     JSR HAPPYFACE
969E*49FF      LDA #$FF
96A0*8D7005     STA FACEFLG
96A3*8D6F05     STA INCFLG
96A6*8D6E05     STA DECFLG

96A9*          AUTOS9A
96A9*9C2C03     STZ SPTIMSEC ;RESET TIMER
96AC*9C2D03     STZ SPTIMTNTH
96AF*4C3995     JMP AUTOS2

96B2*          AUTOS10
96B2*AD7005     LDA FACEFLG ;FACE ON?
96B5*0005      BNE AUTOS10A ;YES
96B7*AD6E05     LDA DECFLG ;DECREASE ARROW?
96BA*F009      BEQ AUTOS10E ;NO

96BC*          AUTOS10A
96BC*206CF0     JSR CLRFACE
96BF*9C6F05     STZ INCFLG
96C2*9C7005     STZ FACEFLG

96C5*          AUTOS10B
96C5*AD6E05     LDA DECFLG ;JUST DECREASED?
96C8*F00A      BEQ AUTOS11 ;NO
96CA*AD2C03     LDA SPTIMSEC ;20 SEC UP?
96CD*C914      CMP #20
96CF*B003      BCS ++5
96D1*4C3995     JMP AUTOS2 ;NO

96D4*          AUTOS11
96D4*9C6F05     STZ INCFLG
96D7*9C7005     STZ FACEFLG
96DA*CE6E05     DEC DECFLG ;= $FF

96DD*          AUTOS11AA
96DD*9C2D03     STZ SPTIMTNTH ;RESET TIMERS
96E0*9C2C03     STZ SPTIMSEC
96E3*AD0C02     LDA DACTMP ;DAC AT 0?
96E6*F010      BEQ AUTOS11A ;YES
96E8*A923      LDA #LOW INT0 ;POWER > 0?
96EA*A064      LDY #HIGH INT0
96EC*20DF67     JSR MOVFM

```

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```
96EF*A9CF      LDA #LOW FPPOWER
96F1*A003      LDY #HIGH FPPOWER
96F3*209468    JSR FCOMP
96F6*3010      BMI AUTOS12 ;NO

96FE*         AUTOS11A
96FE*206E05    BIT DECFLG ;DECREASE ALREADY ON?
96FE*300E      BMI AUTOS11C ;YES

96FD*         AUTOS11B
96FD*20B9EF    JSR DECREASEEFFORT
9700*A9FF      LDA #FF
9702*606E05    STA DECFLG

9705*         AUTOS11C
9705*4C3995    JMP AUTOS2

9708*         AUTOS12
                ;JSR CLRFACE
9708*A9C9      LDA #LOW INT10
970A*A063      LDY #HIGH INT10
970C*20DF67    JSR MOVFM
970F*A9CF      LDA #LOW FPPOWER
9711*A003      LDY #HIGH FPPOWER
9713*20ED64    JSR FSUB ;DECREASE BY 10
9716*A2CF      LDX #LOW FPPOWER
9718*A003      LDY #HIGH FPPOWER
971A*200D68    JSR MOVFM
971D*4C3995    JMP AUTOS2

9720*         AUTOS13
9720*9CA07F    STZ $7FA0 ;0 DAC
9723*9C0C02    STZ DACTMP
9726*9CCF03    STZ FPPOWER
9729*9C7005    STZ FACEFLG
972C*9C6F05    STZ INCFLG
972F*80CC      BRA AUTOS11B

9731*         LIMITCALC ;CALCULATE LIMITS
9731*2033F4    JSR RDYFAC
9734*AE2702    LDX USERID
9737*BD1005    LDA LOWLIM,X
973A*85DA      STA FACLO
973C*207565    JSR NORMAL
973F*A2C0      LDX #LOW FPLOWLIM
9741*A004      LDY #HIGH FPLOWLIM
9743*200D68    JSR MOVFM

9746*2033F4    JSR RDYFAC
9749*AE2702    LDX USERID
974C*BD2505    LDA HIGHLIM,X
974F*85DA      STA FACLO
9751*207565    JSR NORMAL
9754*A2C5      LDX #LOW FPHIGHLIM
```

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Huntsville Macro Assembler 65002 cross assembler for PC-DOS 2.0 v1.92L Page .  
Module: E111F

```

9756*A004      LDY #HIGH FPHIGHLIM
9758*200D68    JSR MOVMF

975E*2033F4    JSR RDYFAC
975E*AE2702    LDX USERID
9761*BD3A05    LDA HFTMAX,X
9764*85DA      STA FACLO
9766*207565    JSR NORMAL
9769*204568    JSR MOVAF
976C*A919      LDA #LOW INT100
976E*A064      LDY #HIGH INT100
9770*20DF67    JSR MOVFM
9773*20E4FD    JSR FPD10
9776*42C4      LDX #LOW FPMAX
9778*A004      LDY #HIGH FPMAX
977A*200D68    JSR MOVMF

977D*A9C0      LDA #LOW FLOWLIM
977F*A004      LDY #HIGH FLOWLIM
9781*20DF67    JSR MOVFM
9784*A9C5      LDA #LOW FPHIGHLIM
9786*A004      LDY #HIGH FPHIGHLIM
9788*20ED64    JSR FSUB ;HIGH - LOW
978B*A941      LDA #LOW INTPT2
978D*A064      LDY #HIGH INTPT2
978F*206566    JSR FMULT ;* 0.2
9792*A263      LDX #LOW FACTMP ;SAVE
9794*A003      LDY #HIGH FACTMP
9796*200D68    JSR MOVMF

9799*A9C0      LDA #LOW FLOWLIM
979B*A004      LDY #HIGH FLOWLIM
979D*200465    JSR FADD ;+ LOW
97A0*A2B1      LDX #LOW FLOWTEST
97A2*A004      LDY #HIGH FLOWTEST
97A4*200D68    JSR MOVMF

97A7*A963      LDA #LOW FACTMP
97A9*A003      LDY #HIGH FACTMP
97AB*20DF67    JSR MOVFM
97AE*A9C5      LDA #LOW FPHIGHLIM
97B0*A004      LDY #HIGH FPHIGHLIM
97B2*20ED64    JSR FSUB ;HIGH - 0.2*DIFF
97B5*A2B6      LDX #LOW FPHIGHTEST
97B7*A004      LDY #HIGH FPHIGHTEST
97B9*200D68    JSR MOVMF

97BC*A9C5      LDA #LOW FPHIGHLIM
97BE*A004      LDY #HIGH FPHIGHLIM
97C0*20DF67    JSR MOVFM
97C3*A99C      LDA #LOW INT5
97C5*A063      LDY #HIGH INT5
97C7*200465    JSR FADD
97CA*A2BB      LDX #LOW FPHIGHTST5
97CC*A004      LDY #HIGH FPHIGHTST5

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```

970E*200D68      JSR MOVWF ;UPPER LIMIT + 5

9701*A9E1        LDA #LOW FLOWTEST
9703*A004        LDY #HIGH FLOWTEST
9705*20F597      JSR LIMITADDRCALC ;CALCULATE LOW LIMIT ADDRESS
9708*4500        LDA ADDR ;SAVE ADDRESS
970A*951A        STA PNT13
970C*A501        LDA ADDR+1
970E*9515        STA PNT13+1
9710*202798      JSR LIMITDSP ;DRAW LINE
9713*A9E6        LDA #LOW FPHIGHTEST
9715*A004        LDY #HIGH FPHIGHTEST
9717*20F597      JSR LIMITADDRCALC
971A*A503        LDA ADDR ;SAVE ADDRESS OF HIGH LIMIT
971C*951C        STA PNT14
971E*A501        LDA ADDR+1
9720*251D        STA PNT14+1
9722*4C2798      JMP LIMITDSP ;NOW DRAW LINE AND RTN

97F5*            LIMITADDRCALC
97F5*20C966      JSR CONUPK
97F8*A94B        LDA #LOW INT31
97FA*A064        LDY #HIGH INT31
97FC*20DF67      JSR MOVWF
97FF*20F064      JSR FSUBT
9802*A946        LDA #LOW INTPT55
9804*A064        LDY #HIGH INTPT55
9806*206566      JSR FMULT
9809*20E664      JSR FADDH
980C*200569      JSR INT
980F*A950        LDA #LOW INT64
9811*A064        LDY #HIGH INT64
9813*206566      JSR FMULT
9816*20D468      JSR QINT
9819*3E          SEC
981A*A980        LDA #$80
981C*E5DA        SBC FACLO
981E*8500        STA ADDR
9820*A93F        LDA #$3F
9822*E5D9        SBC FACMO
9824*8501        STA ADDR+1
9826*60          RTS

9827*            LIMITDSP ;DRAW DOUBLE LINE AT ADDRESS
9827*A003        LDY #3
9829*A90F        LDA #$0F
982B*9100        STA (ADDR),Y
982D*C8          INY
982E*A9FF        LDA #$FF

9830*            LIMITDSP1
9830*9100        STA (ADDR),Y
9832*C8          INY
9833*C000        CPY #0
9835*D0F9        BNE LIMITDSP1

```

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Huntsville Macro Assembler, 65C02 cross assembler for PC-DOS 2.0 v1.92L Page  
Module: Bin1A

```
9837*207FA7    JSR ADD40
983A*4003      LDY #3
983C*490F      LDA #$0F
983E*9100      STA (ADDR),Y
9840*0E       INY
9841*49FF      LDA #$FF

9843*        LIMITDSP2
9843*9100      STA (ADDR),Y
9845*0E       INY
9846*0008      CPY #8
9848*00F9      BNE LIMITDSP2

984A*60       RTS
```

WE CLAIM:

1. A method of calibrating an exercise device containing a rotating wheel and a loading device for applying loads to that wheel, comprising the steps of:

5 rotating a wheel in an exercising device until the wheel attains at least a first predetermined rotational velocity;

allowing the wheel to coast down to a second predetermined rotational velocity during which coasting  
10 period the loading device is not exerting loads on the wheel other than inherent frictional loads;

sensing and recording the time and rotational velocity at periodic intervals as the wheel coasts down from the first velocity to the second velocity;

15 determining the rotational mass moment of inertia of any components of the exercise device that rotate because the wheel rotates;

performing a linear regression analysis on the recorded velocities and times to determine the deceleration  
20 of the wheel and rotating components as a function of velocity; and

deriving the frictional load from rotation of the wheel and the rotating components of the exercise device from the formula Frictional torque equals the Mass Inertia  
25 times the Angular deceleration.

2. A method as defined in Claim 1, wherein the velocity and time data are taken with the wheel rotating between the speeds of at least 23 miles per hour, and 5 miles per hour, and wherein there are sufficient velocity  
30 and time readings that every 20 velocity readings are averaged together to form a series of velocities upon which the linear regression can be performed.

3. A method as defined in Claim 1, comprising the further step of:

35 computing the power required to overcome the frictional load from the formula: Power equals Torque

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times angular velocity.

4. A method as defined in Claim 1, comprising the further step of:

determining the efficiency of the loading device;

5 determining the power output of the loading device by comparing the efficiency of the loading device with a second loading device for which the power output is known; and

10 adjusting the loading device to account for the frictional losses and the efficiency of the loading device.

5. A method as defined in Claim 4, wherein the efficiency is determined by performing a linear regression analysis to determine the power dissipated by the loading device at a predetermined speed, and by performing a linear regression analysis to determine the power which the  
15 loading device applies to the wheel.

6. A method as defined in Claim 4, wherein said loading device comprises an electrical device which exerts a load on the wheel where the load can be varied by varying  
20 the voltage applied to the loading device, and wherein the power dissipated is determined by the steps comprising:

rotating the wheel until the wheel attains at least a third predetermined rotational velocity;

25 allowing the wheel to decelerate to a fourth predetermined rotational velocity;

applying a constant decelerating force from the electrical device in order to further decelerate the wheel as it decelerates from the third to the fourth velocities;

30 sensing and recording both the rotational velocity of the wheel and the voltage output by the electrical device at periodic intervals of time as the wheel decelerates from the third velocity to the forth velocity;

35 performing a linear regression analysis on the recorded wheel velocity and the square of the voltage

output from the coast down between the third and fourth velocities to determine the deceleration of the wheel and rotating components as a function of velocity; and

5 wherein the power output by the loading device is further determined by the step comprising:

performing a linear regression analysis on the velocity and on the deceleration times the velocity from the coast down between the third and fourth  
10 velocities in order to obtain linear regression constants for use in determining the power applied.

7. A method of accurately and realistically simulating environmental loads in a stationary exercise apparatus, comprising the steps of:

15 mounting a bicycle in a support apparatus so a rear tire of the bicycle rides against at least one roller;

connecting a loading device to the exercise apparatus so the loading apparatus can exert a controllable load on the rear tire; pedaling the bicycle until the rear tire  
20 reaches a first predetermined rotational velocity;

letting the rear tire coast down to a second predetermined velocity while the loading device exerts no loads other than its inherent frictional loads;

sensing and recording the velocity of the rear tire at  
25 periodic time intervals as the tire coasts from the first velocity to the second velocity;

determining the rotational mass moment of inertia of any components of the bicycle and support apparatus that rotate with the wheel during the coast down period;

30 performing a linear regression analysis on the recorded velocities and times to determine the deceleration of the rear tire and rotating components as a function of velocity; and

deriving the frictional load from rotation of the tire  
35 and the rotating components from the formula: Frictional torque equals the Mass Inertia times the Angular

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deceleration.

8. A method as defined in Claim 7, further comprising the steps of:

determining the efficiency of the loading device;

5 determining the power output of the loading device by comparing the efficiency of the loading device with a second loading device for which the power output is known; and

10 adjusting the loading device to account for the frictional losses and the efficiency of the loading device.

9. A method as defined in Claim 8, wherein the linear regression step comprises:

15 performing a linear regression analysis on the recorded times and velocities between a third velocity and the second velocity to determine the deceleration of the rear tire and rotating components as a function of velocity, where the third velocity is between the first and second velocities.

20 10. A method as defined in Claim 9, further comprising the step of:

connecting a flywheel to the support apparatus so the rear tire causes the flywheel to rotate and simulate the inertia of a rider and bicycle, and where the mass moment of inertia includes the inertia of the flywheel.

25 11. A method as defined in Claim 10, wherein the loading device comprises an alternator which can exert a controllable load on the rear tire by controllably varying the voltage applied to the alternator, and wherein the efficiency of the alternator is determined by determining  
30 the power dissipated by the alternator and the power output by the alternator, the power being dissipated being determined by comprising the steps of:

rotating the wheel until the wheel attains a fourth predetermined rotational velocity;

35 allowing the wheel to decelerate to a fifth predetermined rotational velocity;

applying a constant decelerating force from the alternator in order to further decelerate the wheel as it decelerates from the fourth to the fifth velocity;

5       sensing and recording the rotational velocity of the wheel and the voltage output by the electrical device at periodic intervals as the wheel decelerates from the fourth velocity to the fifth velocity;

10       performing a linear regression analysis on the recorded wheel velocity and the square of the voltage to determine the deceleration of the wheel and rotating components as a function of velocity; and wherein

the power output by the alternator is determined by the steps comprising:

15       performing a linear regression analysis on the velocity and on the deceleration times the velocity in order to obtain linear regression constants for use in determining the power applied.

20       12. An exercise device which realistically simulates the pedal resistance, body position and feel of riding a bicycle, including performance periods when the user is not sitting on the saddle but is instead leaning over the front handlebars and essentially standing on the pedals, comprising:

25       a stationary frame for mounting components of a bicycle, said bicycle including a rear wheel, a rear tire and a rear axle, a frame, a seat, a front fork, handlebars and pedals, wherein said stationary frame comprises:

30       rear axle support means for connecting to opposite ends of said rear axle without preventing rotation of said rear wheel and tire, said rear axle support means constraining said rear axle, wheel and tire to move along a predetermined path;

35

fork support means for connecting to and

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supporting said front fork, said fork support means being movable in response to a shift in the weight of a rider;

5 a roller mounted to said frame so as to frictionally engage said rear tire of the bicycle when said rear axle is connected to said rear axle support means, said roller and said rear axle support means cooperating to support said rear wheel and tire when  
10 said rear axle is connected to said rear axle support means so as to maintain frictional contact between said roller and said rear tire whose axle is connected to said rear support means, as the weight of a rider is shifted toward said fork support means, so as to prevent slippage between said roller and said rear  
15 tire;

flywheel means communicating with said roller to simulate the momentum a rider and bicycle achieve during actual riding of a bicycle;

20 variable load-applying means communicating with said roller for applying variable loads to said roller to simulate variations in the load encountered during actual riding of a bicycle; and

25 calibration means for determining the friction retarding the wheel from rotating so the variable load-applying means can compensate for said friction.

13. An exercise device as defined in Claim 12, wherein said rear axle support means comprises at least one rotatable member constrained to rotate about an axis substantially parallel to the rotational axis of a rear  
30 wheel of the bicycle when said wheel is connected to said rear axle support means.

14. An exercise device as defined in Claim 12, wherein said rotational axis of said rear axis support means and the rotational axis of said roller are located on  
35 opposite sides of a substantially vertical plane through a rear axle of a bicycle connected to said rear axle support

means.

15. An exercise device as defined in Claim 12, wherein said predetermined path is arcuate.

16. An apparatus for use in exercising with a  
5 bicycle, comprising:

rotatable support means for supporting a rear wheel and tire of a bicycle by frictionally engaging said tire;

movable support means cooperating with said rotatable  
10 support means to support said rear wheel and tire, said movable support means constraining said rear wheel and tire to move along a predetermined path to bring said tire into frictional engagement with said rotatable support means;

inertia means communicating with said rotatable  
15 support means to simulate momentum during actual riding of a bicycle;

variable load-applying means communicating with said rotatable support means for applying variable loads to said rotatable support means in order to simulate variations in  
20 loads encountered during actual riding of a bicycle; and

calibrating means to calibrate the friction in rotating said rear wheel so said variable load-applying means can compensate for said friction.

17. An apparatus as defined in Claim 16 wherein said  
25 calibrating means further comprises means for determining the efficiency of said variable load-applying means so said load-applying means can compensate for the inefficiencies of said load-applying means.

18. An apparatus as defined in Claim 17, wherein said  
30 movable support means comprises pivoting support means which pivot about an axis substantially parallel to the rotational axis of the rear wheel and tire supported by said support means.

19. An apparatus as defined in Claim 17, further  
35 comprising fork support means for connecting to and supporting a front fork of a bicycle when the rear wheel of

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said bicycle is supported by said rotatable support means and said pivoting support means, said fork support means being connected to said pivoting support means such that movement of said fork support means cooperates with said  
5 pivoting support means to maintain frictional contact between said rotatable support means and said rear tire of said bicycle when said bicycle is supported by said rotatable support means and said pivoting support means.

20. An apparatus as defined in Claim 19, further  
10 comprising joint means on said front fork support means and said rear axle support means for positioning said front axle support and said rear axle support member in adjacent relationship to said frame to form a smaller, portable configuration of said apparatus.

21. An exercise device as defined in Claim 12, further  
15 comprising decreased heart rate means operating when said person's heart rate is below a first predetermined lower limit in order to increase said heart rate, said decreased heart rate means determining whether the loads exerted by  
20 the variable load means just increased and if so whether said load has been unchanged for a predetermined period of time, said decreased heart rate means causing said variable load means to increase the load if the load is below a predetermined maximum value.

22. An exercise device as defined in Claim 21 further  
25 comprising increased heart rate means operating when said person's heart rate is above a third predetermined limit in order to decrease said heart rate, said increased heart rate means determining whether the load exerted by said  
30 variable load means just increased, and if said load has been at an increased level for a predetermined time said increased heart rate means causes said variable load means to increase the load, said increased heart rate means decreasing said load exerted by said variable load means if  
35 said load has not just decreased and if said load is not below a predetermined value.

Fig. 1

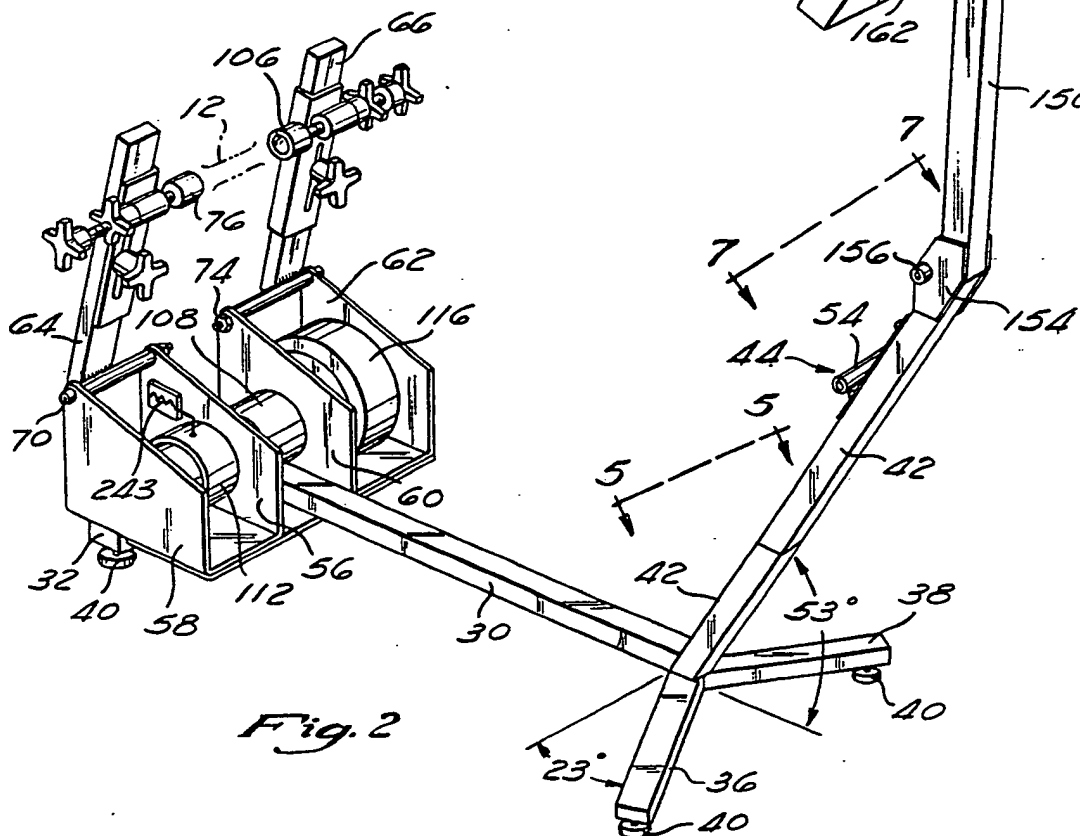
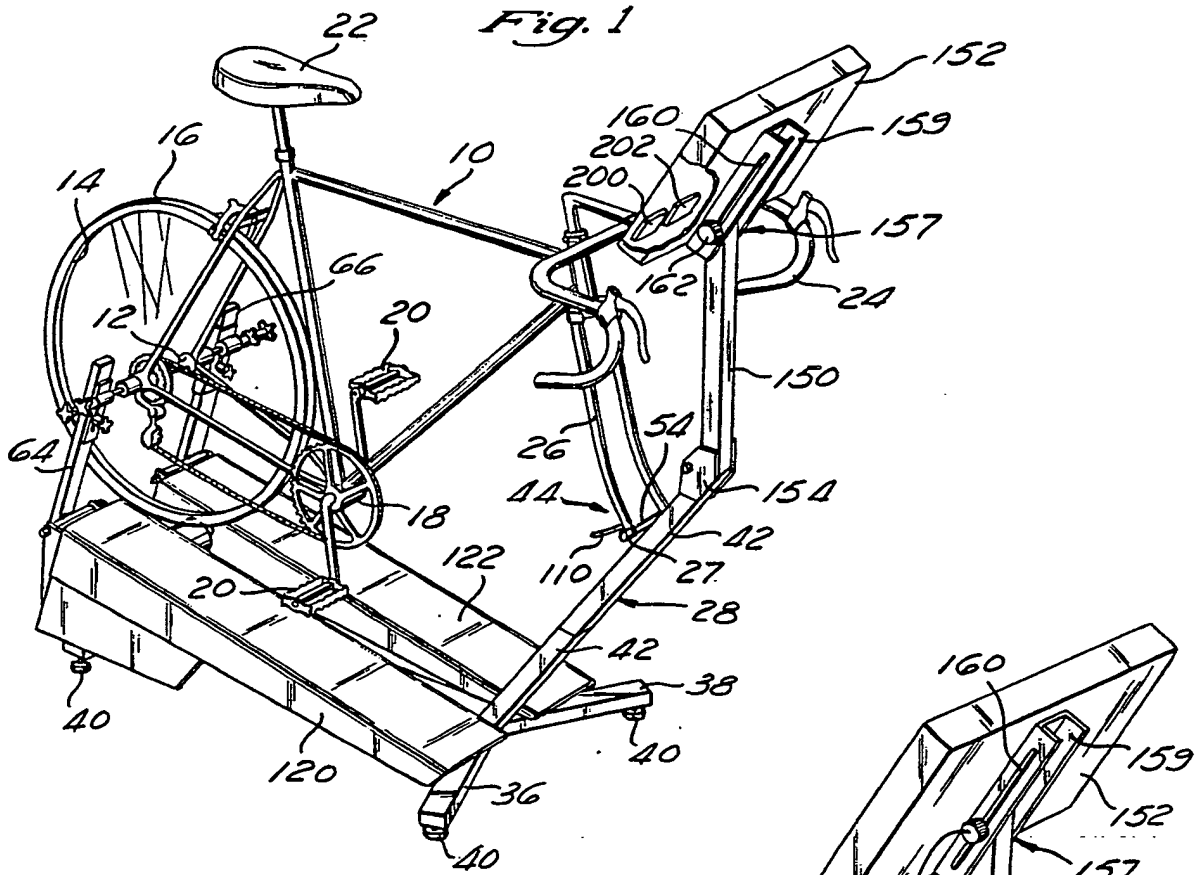


Fig. 2

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Fig. 3

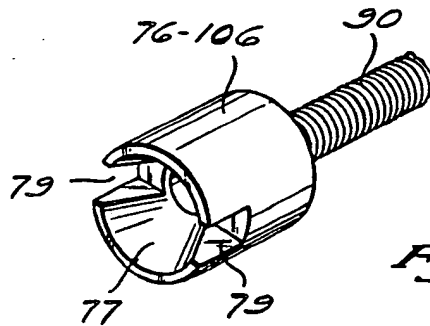
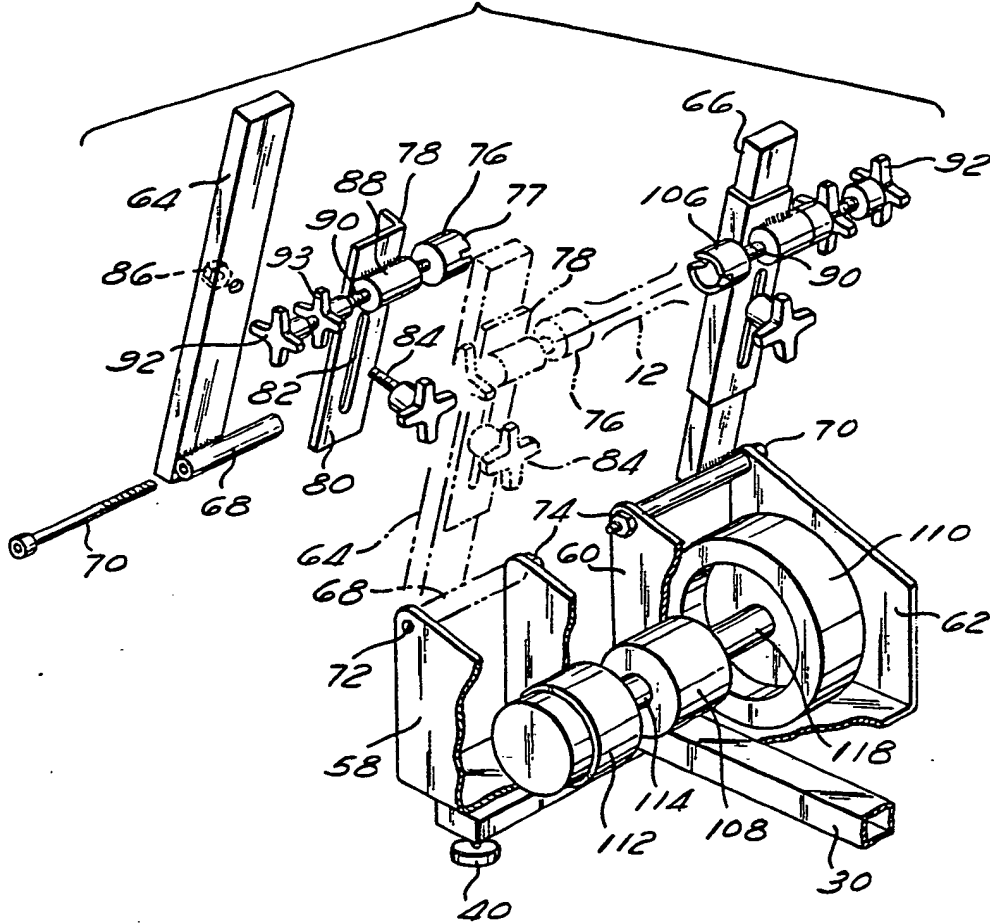
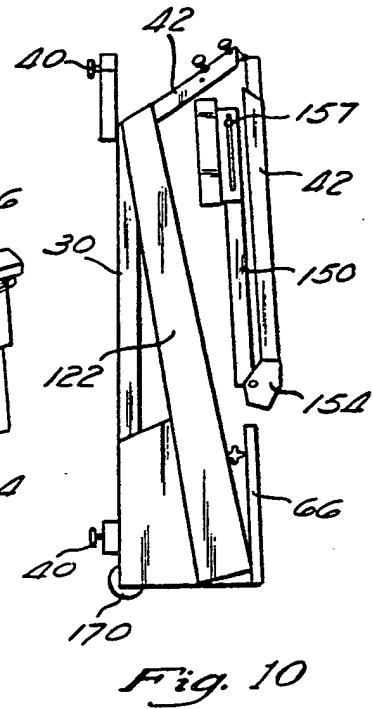
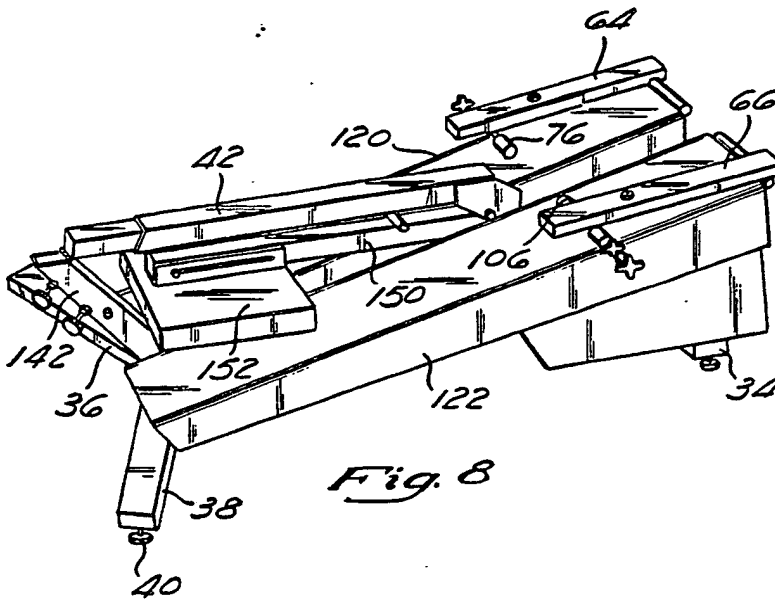
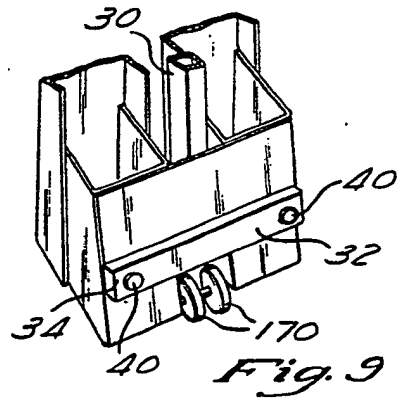
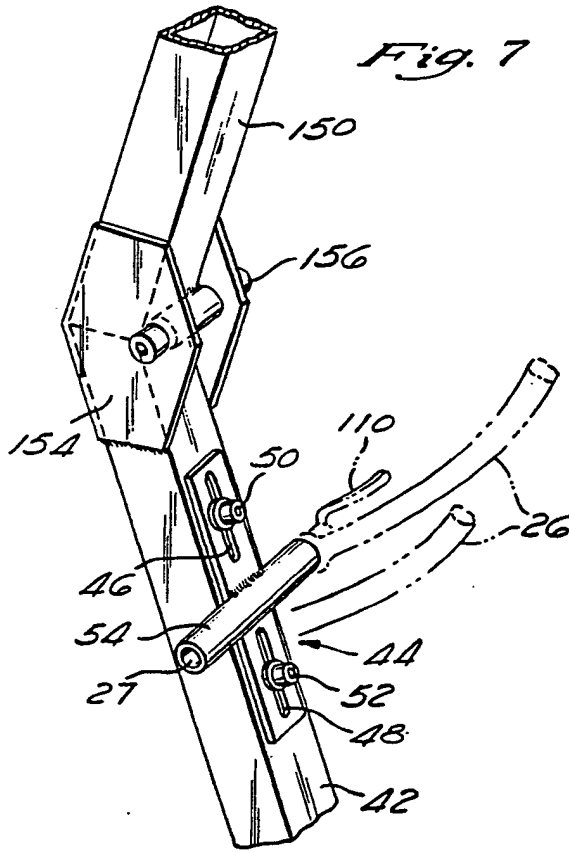


Fig. 4



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Fig. 11

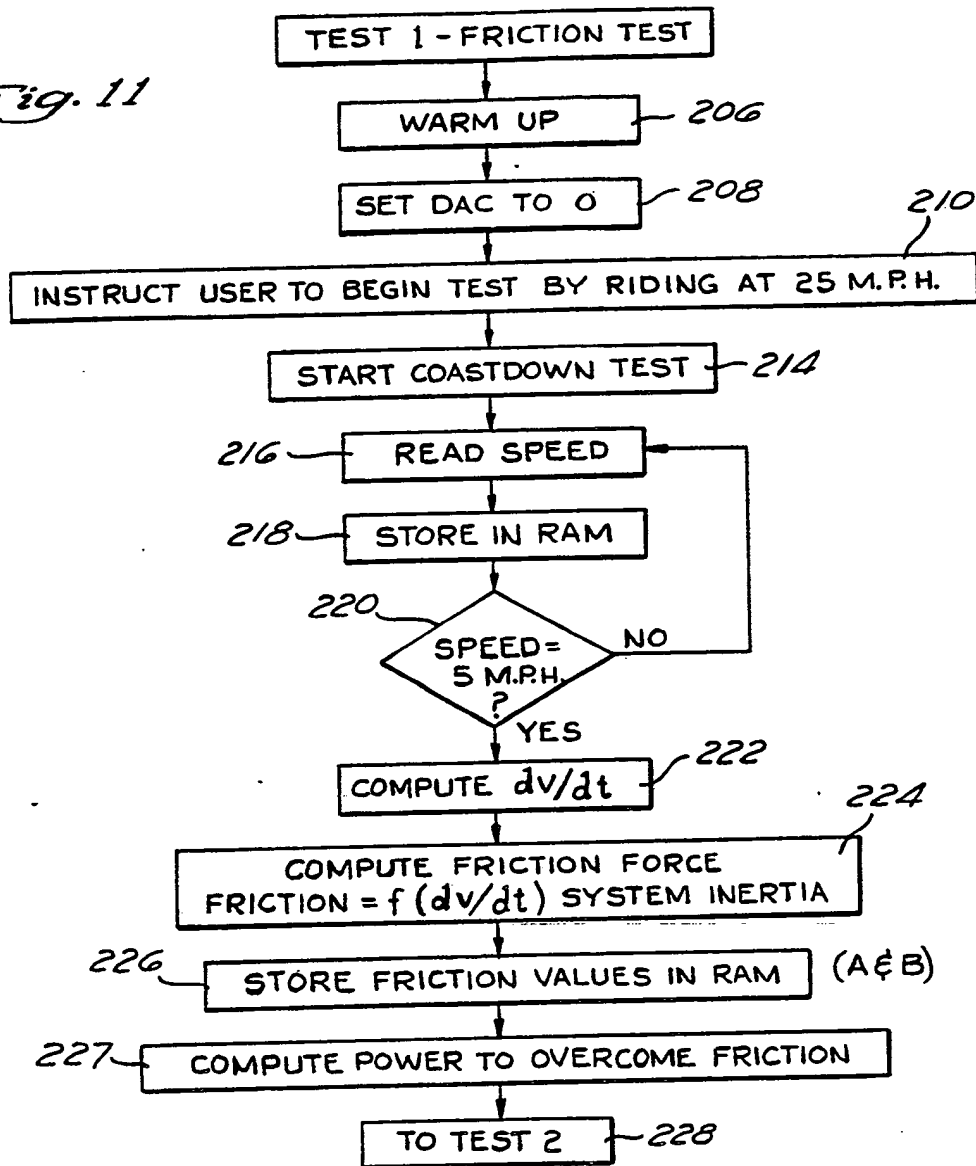
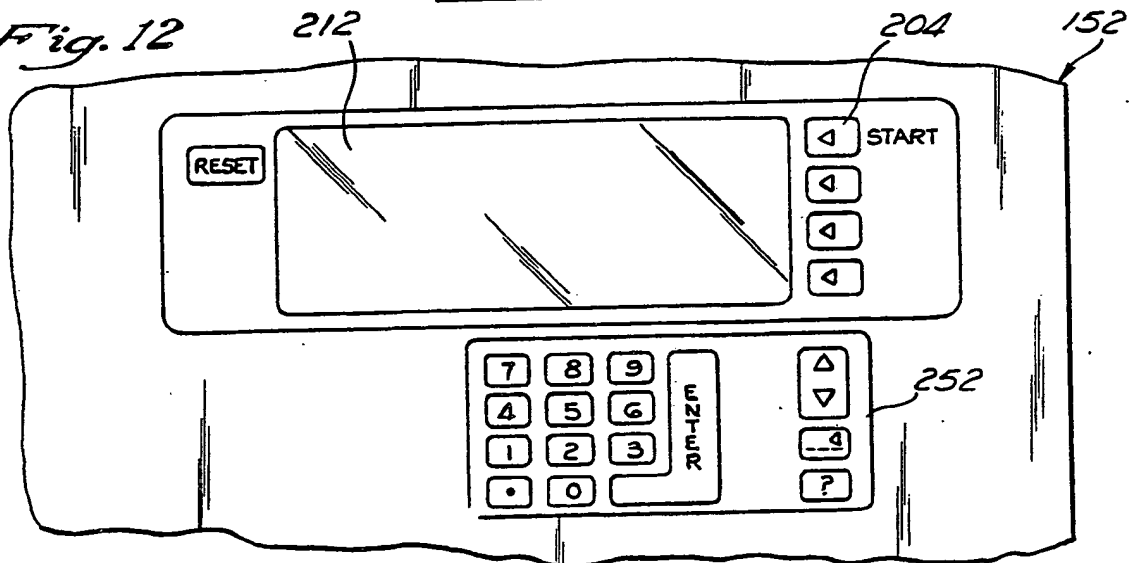
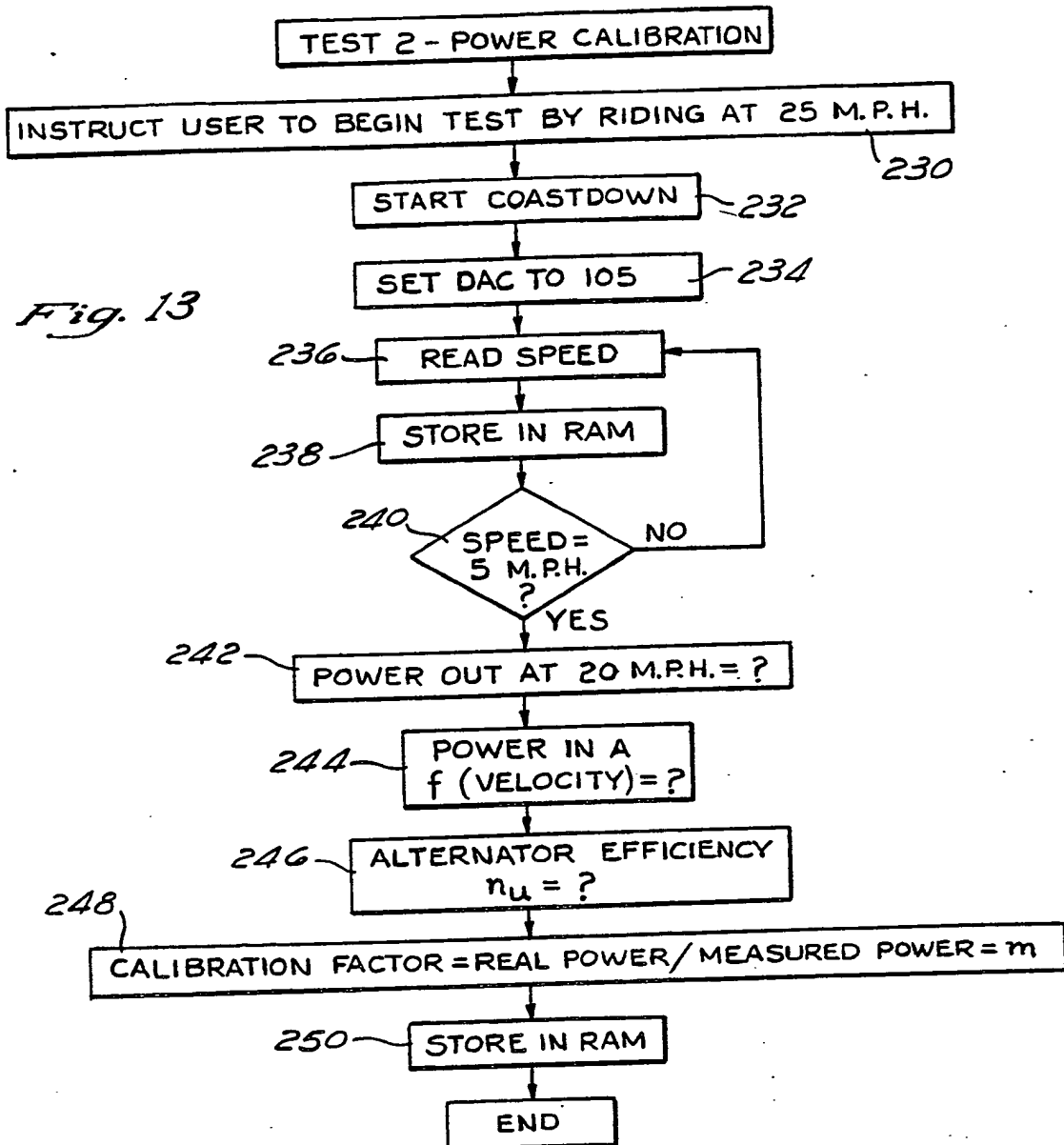


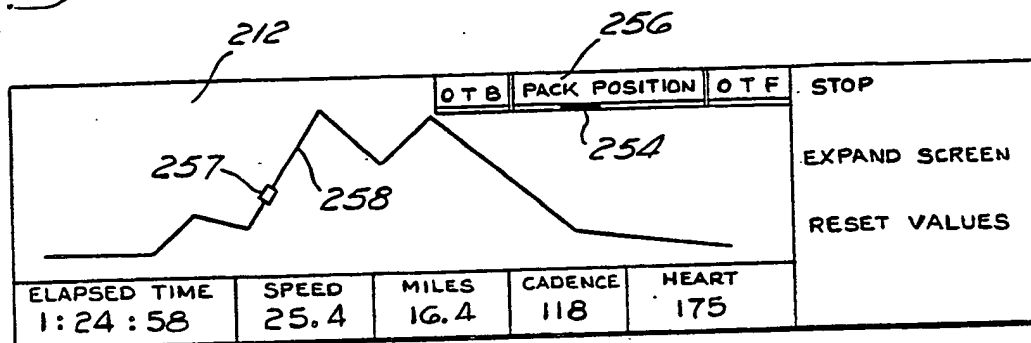
Fig. 12



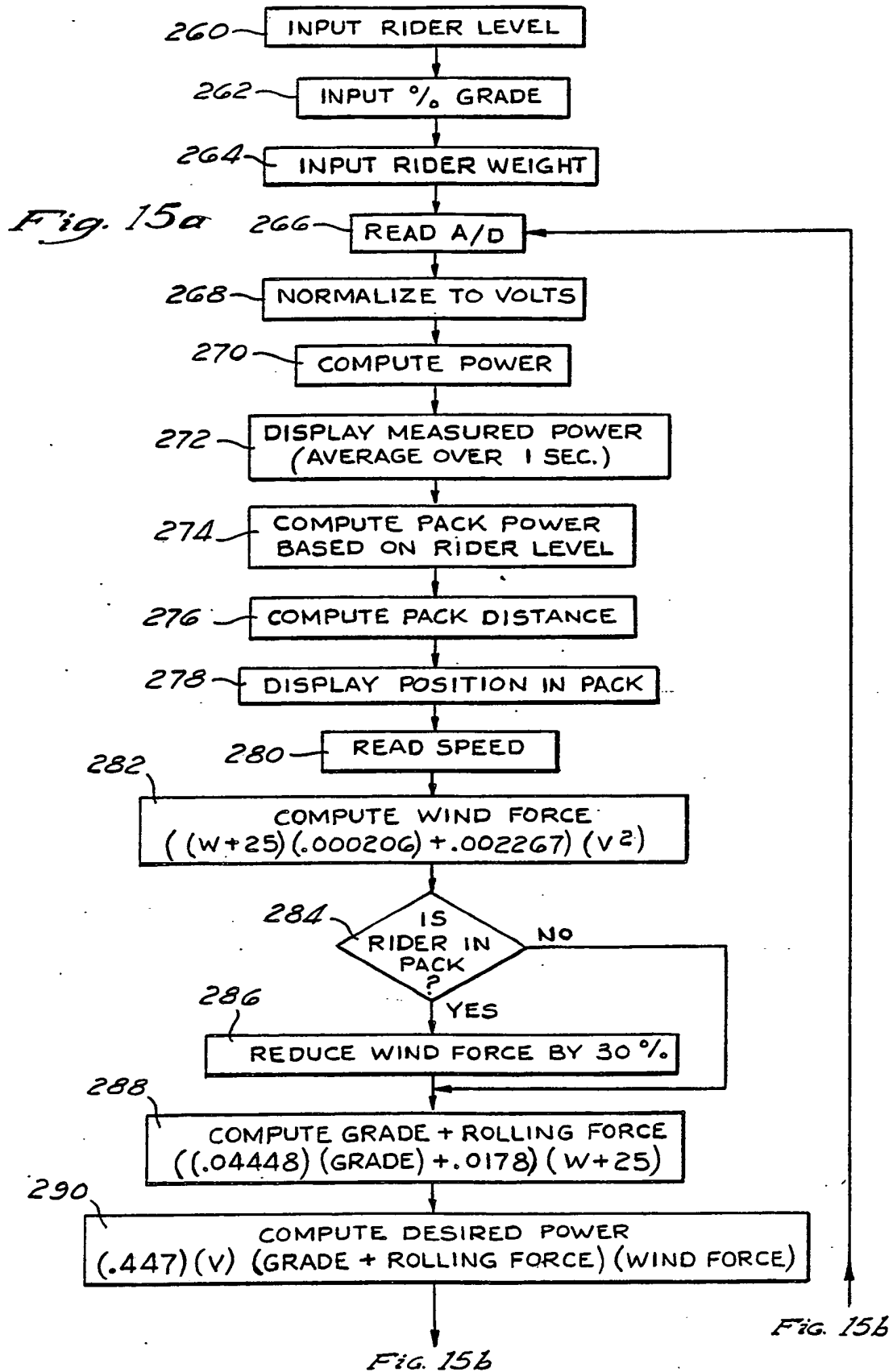
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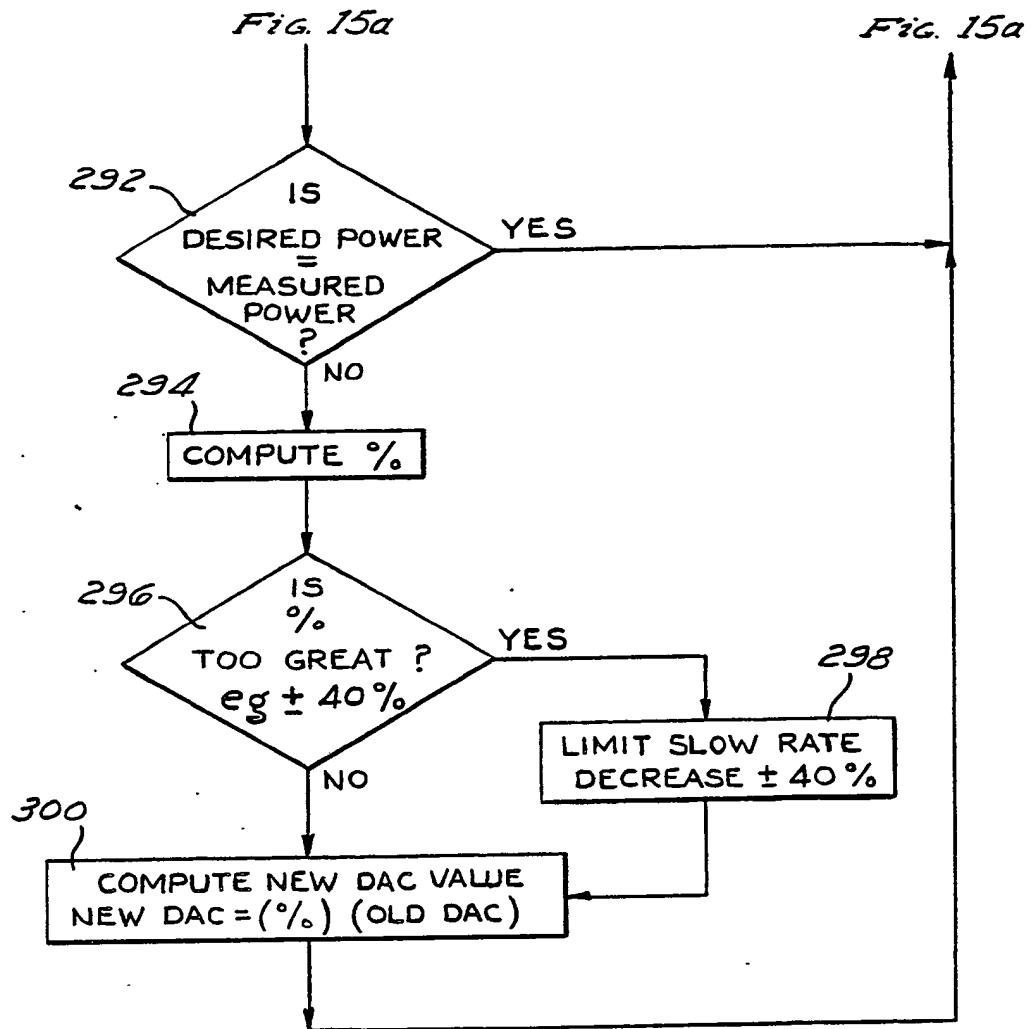
*Fig. 14*



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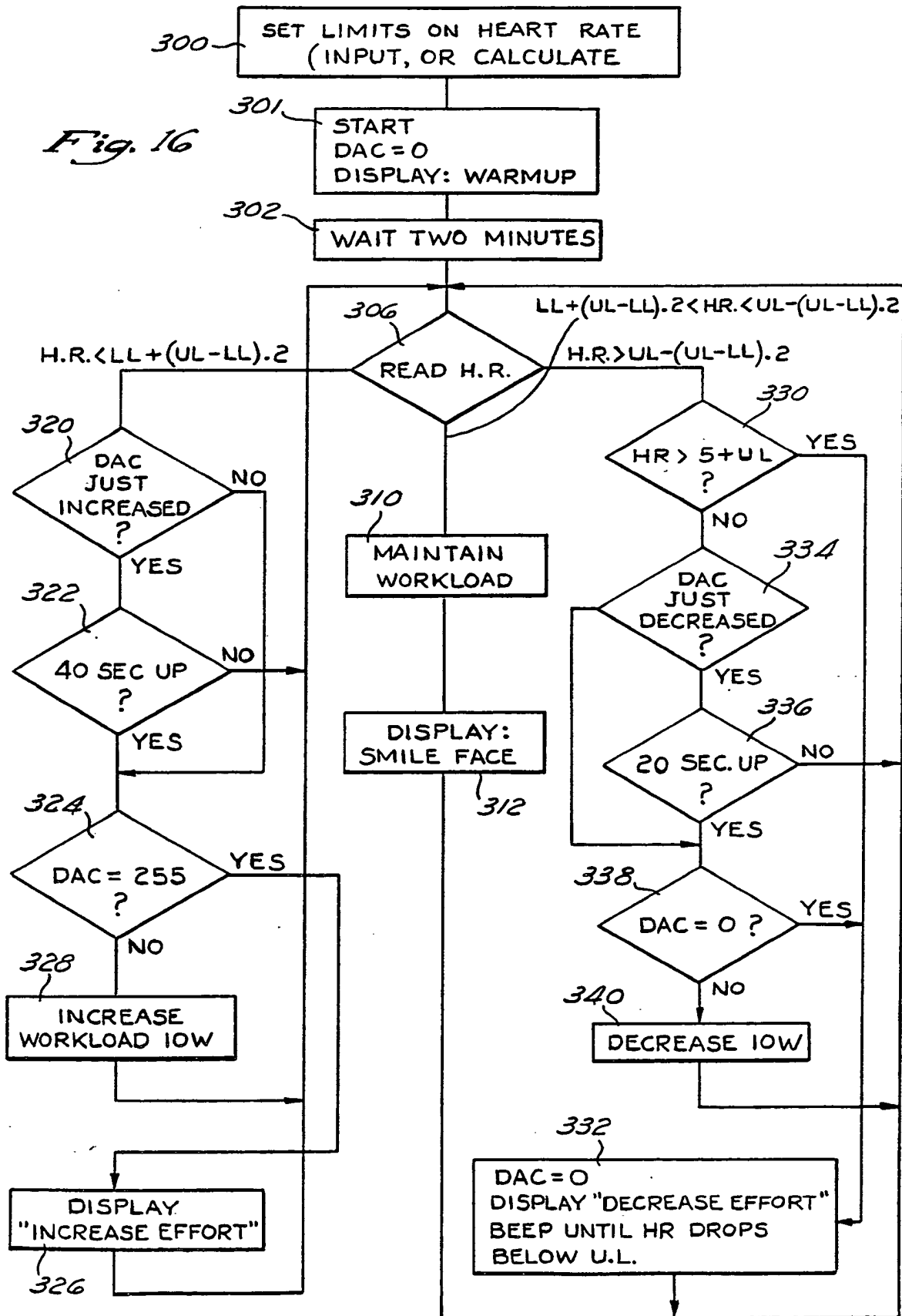
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*Fig. 15b*

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Fig. 16



# INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/02905

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC (4) : A63B 21/00 21/24		
US. CL. : 272/73,129, dig. 6		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
U.S.	272/73,129, Dig. 5, Dig. 6 73/379 128/706	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>		
Category <sup>*</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
Y	GB,A, 0,017,570, (THOMPSON), 15 August 1898, shows roller g, resistance r, pivot e, front and rear supports d. See page 1 lines 15-21; page 2 lines 19-25.	12-20
Y	DE,A, 2,950,605, (KEIPER), 19 June 1981, shows pivotal rear axle supports 17 (Fig 1) and variable load means (Fig 5).	12-20
Y	US,A, 3,845,756, (OLSSON), 05 Nov. 1974, shows control means which monitors person's heart rate and adjusts the load. See col. 1 lines 15-20; col. 2 lines 17-24.	21-22
A	US,A, 4,441,705, (BROWN), 10 April 1984, shows front fork support 14, rear wheel load means 22. See column 4, lines 13-20.	12-20
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>*</sup> Special categories of cited documents: <sup>10</sup></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Δ" document member of the same patent family</p> </div> </div>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
21 October 1988	11 JAN 1989	
International Searching Authority	Signature of Authorized Officer	
ISA/US	S. R. Crow <i>S.R. Crow</i>	

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